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ABSTRACT

The challenge of professionalism is addressed in the 32 papers published in this Proceedings. The papers and their authors include: "New Concepts of Management: Challenges of Professionalism" (keynote address, Herman Birnbrauer); "Alternate Financing of Campus Projects" (F. Louis Fackler); "An Automated Work Order System for the Small University" (Charles W. Jenkins); "A Computerized Maintenance Management System for the Personal Computer" (P. Marques Davidson); "Making Architects/Engineers Respond to Physical Plant Needs" (Dennis P. Cesari); "State-of-the-Art Incineration: Design, Procurement & Operations" (Lawrence G. Doucet); "Application of Oxygen Trim Control to Small Packaged Boilers" (Robert L. Nelson); "Managing Maintenance Information, Part II" (Pieter J. van der Have); "Creative Funding of Energy Conservation Projects: Positive Cash Flow" (Eugene A. Simko, Thomas C. Chen); "The Impact of Installing a New Telecommunications System on Physical Plant Administrators" (John M. Casey); "Coping with Asbestos" (John Skubal, Harold Harp); and "Method for Investigating Feasibility for Contracting Physical Plant Services" (Howard A. Wells, Jr.). (SW)

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Proceedings of

The Seventy-First
Annual Meeting
# of The Association of
Physical Plant Administrators
# of Universities and Colleges

Challenges of Professionalism

Vice President for Educational Programs:
Jack Hug

June 17-20, 1984 Columbus, Ohio

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Papers and individual photographs supplied by authors/speakers.

Table of Contents

Introduction v

In Appreciation vi

Photo Highlights of the Annual Meeting vii

MONDAY, JUNE 18

KEYNOTE ADDRESS: New Concepts of Management: Challenges of Professionalism/ *Herman Birnbrauer* 3

Alternate Financing of Campus Projects/*F. Louis Fackler* 8

An Automated Work Order System for the Small University/*Charles W. Jenkins* 16

Informing the Customer/*James T. Mergner* 29

Quality Circles in Physical Plants/*Shelley K. Merrill* 37

Variable Volume Fume Hood System/*Dennis Buchenholz* 42

A Computerized Maintenance Management System for the Personal Computer/ *P. Marques Davidson* 58

The Physical Plant Administrator's Role in Campus Master Planning/*William J. Griffith* 73

Making Architects/Engineers Respond to Physical Plant Needs/*Dennis P. Cesari* 78

How to Pick a Maintenance Management System/*C.K. Gold* 115

State-of-the-Art Incineration: Design, Procurement & Operations/*Lawrence G. Doucet* 123

Computerized Planned Maintenance/*Richard S. Jacobs* 149

TUESDAY, JUNE 19

Misconceptions of Physical Plant Administrators/*Edwin B. Feldman* 165

Computerized Maintenance Planning and Estimating System/*Bernard T. Lewis* 171

Detecting Electrical and Building Thermal Envelope Problems/*H.Z. Lewis* 183

Organizing an Effective Physical Plant Department for the 1980s and Beyond/ *Manual X. Patino* ... 195

Procedures Manual for the Physical Plant/*William A. Daigneau* ... 205

Application of Oxygen Trim Control to Small Packaged Boilers/*Robert L. Nelson* ... 212

Managing Maintenance Information, Part II/*Pieter J. van der Have* ... 238

An Organized Department Means Motivation/*George B. Wright* ... 254

Creative Funding of Energy Conservation Projects: Positive Cash Flow/ *Eugene A. Simko and Thomas C. Chen* ... 256

Performance Evaluation Made (Almost) Easy/*Phyllis Rossiter Forbes* ... 268

Comprehensive Planning for Employee Training and Development/*William D. Middleton* ... 274

Deferred Maintenance: A Case Study in Funding/*Bruce Toro and Gordon Muir* ... 280

WEDNESDAY, JUNE 20

HIGHLIGHT ADDRESS: Professionalism: The Art of Being Excellent, Exemplary, and Elite/ *Arliss L. Roaden* ... 295

Telecommunications Panel

The Impact of Installing a New Telecommunications System on Physical Plant Administrators/ *John M. Casey* ... 301

An Administrator's Guide to Changing Telephone Systems/*Phyllis Rossiter Forbes* ... 318

Hazardous Materials Panel

Coping with Asbestos/*John Skubal and Harold Harp* ... 327

Overcoming the PCB Hurdles/*Charles R. Nuss* ... 342

Living with Asbestos/*John H. Thomson* ... 351

Contracting Panel

Grounds Maintenance Contracting Versus In-house Labor/*Larry G. Steward* ... 362

Method for Investigating Feasibility for Contracting Physical Plant Services/ *Howard A. Wells, Jr.* ... 370

Speakers' Names and Addresses ... 381

Exhibitors at the 71st Annual Meeting ... 384

Registrants at the 71st Annual Meeting ... 389

Introduction

The *Proceedings of the Seventy-First Annual Meeting of the Association of Physical Plant Administrators of Universities and Colleges* contains 32 papers presented at the meeting June 17-20, 1984 in Columbus, Ohio. The meeting theme was Challenges of Professionalism. Readers desiring more information on individual papers should contact the authors directly.

All but one presentation made at this year's annual meeting are included in the 1984 *Proceedings*. This year, for the fourth year in a row, we requested that the speakers submit camera-ready papers, thus making publication more efficient and less costly than would otherwise be the case.

One copy of these *Proceedings* is being mailed automatically to all Institutional, Affiliate, and Subscribing members of APPA. Others who were official registrants at the meeting may also receive one complimentary copy upon written request as long as the limited supply lasts. Additional copies may be purchased from APPA for $15 each to APPA members, $21 to nonmembers.

The 1984 *Proceedings* were compiled and produced by Steve Howard.

Paul T. Knapp, CAE
Executive Director
September 1984

In Appreciation

APPA would like to thank the following individuals representing APPA member institutions for their contributions to the success of the 71st Annual Meeting.

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Photo Highlights of the Annual Meeting

APPA'84 COLUMBUS, OHIO
CHALLENGES OF PROFESSIONALISM

Monday, June 18

APPA'84 COLUMBUS, OHIO
CHALLENGES OF PROFESSIONALISM

New Concepts of Management: Challenges of Professionalism

By Herman Birnbrauer, P.E.
Institute for Business and Industry

- **Business Purpose**

  It is necessary for management to periodically establish their business purpose. P. Drucker in his book "Managing in Turbulent Times" suggests that all managers meet with their subordinates regularly to re-affirm their business purpose and also to seek methods by which they can improve. At the same time, the manager can ask what help and support is required of him/her.

  I likened this to our deck chair of life and which way we are facing. Do we live in the past and use the past to chart our future? Do we live in the future and disregard the past? Or are we still trying to unfold our deck chair?

- **Ethics**

  Every manager must establish a code of ethics. What do you stand for? Our look at the future indicates that open, honest and aboveboard will produce the best results for everyone. There will be a demand for more involvement on the part of the workforce and they will want a chance to influence what is happening. They will want to do things with people and not have management do it to them. A need for trust is surfacing in all aspects of our activities. Trust, credibility, respect and loyalty will become increasingly important and this will necessitate our acquiring the open, honest and aboveboard approach always.

- **Commitment**

  The key to creating an atmosphere where motivation can take place is in commitment. People are going to have to be permitted to claim ownership to a task, an assignment, a department and a career. They will need the opportunity to buy in. Our problem is that now many people are involved but too few are committed. I define an involved worker as the kamikaze pilot that flew 100 missions.

- Hunters & Campers

I define those workers that are performing the tasks that the organization has defined as the business purpose as hunters. All the other people in the organization are campers. Their task is to do whatever is necessary so that the hunters can hunt full time.

A supervisor is added to make sure the hunters hunt and that they do it correctly. The manager should be at the next level to do those things necessary to determine what hunt the hunters should be on. These managers spend time planning and setting priorities. The department head should be there to provide all the resources necessary for a successful hunt.

If this process is to be productive, the workers and the supervisors must be more left brain dominant - logical, structured, sequential, step-by-step. Everyone should understand the rules and procedures. The managers must acquire the ability to shift their level of thinking to the right side of their brain and become more global, imaginative, creative and flexible. They must make decisions without all the information and their accuracy average, using this global intuitive method must be very high.

These managers must have clear visionary thinking that they can translate into useable information for the workers and supervisors to implement.

- Pride

It is vital that managers begin to create a culture of pride in their organizations. They must become good places to work, everyone must be proud to be there and positive reinforcement should be used to put pride back into our workplace. Rewarding mediocre performance should stop. Our commitment should be to excellence.

- Objectives

Managers of the future will spend time and effort setting goals and objectives with their groups. These objectives will reflect the workers own value system. It will provide a focus for everyone. We must focus on those things we are responsible for and can control. Yogi Berra said, "If you don't start out to go someplace - you'll probably end up someplace else." We all need to stop-ready-fire-aim and go back to the basics.

- Networks

Everything now available about the future suggests that we will replace hierarchies with networks. We will need to create networks of support. High level performance managers will identify those people who have a stake in the outcome and then build a coalition of support and interest. Managers will learn to manage whatever system they find themselves a part of.

Management by Wandering Around

"In Search of Excellence" by T. Peter and R. Waterman discusses the advisability of management being visible with their peers, subordinates and clients.

This book also discusses simultaneously loose and tight properties. A tough environment that holds people accountable while, at the same time, being very supportive. You are expected to do your job, but if you should need help there will be support.

- Lemonade Rule

The definition of a lemon worker is one who you wished worked for someone else. Statistics indicate that our fair share of lemons is six out of every hundred workers. Do you have more than your fair share? The lemonade rule says that whenever you have a lemon, open up a lemonade stand. Of course, the way to make lemonade is to squeeze the lemon and then add some sweetener (positive reinforcement). Some of us are guilty of squeezing everyone instead of just focusing on the lemon. In my book, "A Positive Approach to Discipline" I stress the need to put people in a position to be doing good work and then reinforce them. There is no need for any of us to have anything less than an excellent workforce.

- Scorekeeping

  Most people, when they play cards, want to keep score. In fact, many won't play without keeping score. I believe we are the same at work. We all want timely, specific, useable information about the hand we just played. We don't want someone to keep score and then tell how we did once a year or even once a week. We want it right after the hand. We want to know how we did - what we can do to improve and so on. How do your people get their score?

- Consideration

  We need to realize that it will be necessary in the future to be more loyal, concerned and considerate of our fellow employees. This is best illustrated with my requesting you to make me a gun cabinet that I will pay you for. When you deliver it, I pay you for it, and then smash it with a sledge hammer. How do you feel about making me another one? Even though I am willing to pay well, few people would make another one. When asked why, many people say, "I put a part of me in that cabinet, and I care what and how it is used." Do we, in our daily activities, smash people's gun cabinets? More than likely, yes. We do by rushing someone to get something done and then not using it or writing all over someone's report, etc. Can we learn to be more considerate of other peoples' feelings about the work they do?

I suggest that we are all going to have to change.

You cannot become what you want to
by staying the way you are.
Change is required.

I WISH YOU ALL GOOD LUCK AND A SAFE WALK ALONG THE PATHWAY OF YOUR PROFESSION!

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Alternate Financing of Campus Projects

By F. Louis Fackler
University of California Santa Cruz

Some of us are old enough to remember when the motto for financing campus facilities was as simple as the Biblical admonition: "Ask and you shall receive." Well, perhaps funding was not quite that easy, but certainly during the great building boom of the '50s and '60s we looked toward our state governments, or, in the case of private institutions, our governing boards, to fund the facilities which were needed. Since the early '70s, energy and maintenance costs have skyrocketed and funding has become more and more difficult to obtain. The securing of funds for needed capital and major maintenance projects has not been easy for any of us and we are now in the position of scrounging for every dollar we can get.

Given this financial environment, third party, or alternate financing, provides an opportunity to obtain capital, retrofit and maintenance projects without initial capital investment by the institution.

The key to successful alternate financing is to identify projects which (1) can reduce future operating expenses to the extent that such savings will be sufficient to pay back the capital cost over a reasonable time, and (2) can generate income tax credits and deductions which will stimulate investor interest. There has to be something in it for everyone to make alternate financing work. Fortunately, energy projects including solar heating systems, cogeneration systems, and energy retrofit projects are prime candidates for alternate financing.

The purpose of this paper is to provide guidelines for considering alternate financing based on experience gained at the Santa Cruz campus of the University of California and other locations. We will discuss: (1) tax benefits needed to stimulate investor interest, (2) items to be evaluated in considering alternate financing, (3) preparation of a Request for Proposal, and (4) methods of alternate financing including financial arrangements between the institution and the developer.

The Santa Cruz Campus

In order to bring recent experience at Santa Cruz into context, I would like to briefly review the Santa Cruz campus in relation to the rest of the University of California and the political climate within the State of California in encouraging alternate financing for energy projects.

The University of California, Santa Cruz is located approximately seventy-five miles south of San Francisco, at the north end of Monterey Bay. The campus is one of nine campuses making up the University of California system and its sister campuses include the University of California Berkeley, and UCLA. The campus has 6800 students and is located on a 2,000 acre site overlooking Monterey Bay and the Pacific Ocean. The campus opened in 1965 and there are now approximately 2.4 million square feet of building space. Approximately 40 percent of this space is dedicated to student housing. The Santa Cruz campus has been a leader in energy conservation, reducing unit energy consumption by more than 50 percent since 1973.

The State of California has encouraged energy projects through both legislative and administrative action. A 50 percent tax credit is provided for alternate energy projects.

The State, through its Energy Assessments Office and State Energy Commission, has encouraged alternate financing of cogeneration and solar energy projects for State-supported facilities. Recent legislation has made it possible to use purchased utility operating funds to pay for energy provided by third parties. Such energy purchases can be at no greater cost than energy purchased from the local utility company. In this way, normal utility operating budgets can pay for third party investment in energy projects. A portion of energy savings would be shared with the institution.

The State Public Utility Commission (PUC) has approved standard agreements whereby utility companies are required to purchase surplus electricity from cogeneration plants at a cost based on the marginal cost of generating power. Also, the PUC has mandated utility company rebates which apply to University dormitories as well as to individual residences.

Tax Considerations

Tax exempt educational institutions cannot utilize the various tax credits and incentives allowed for business investment. In pursuing alternate financing, we are asking private investors to provide the capital and are presenting them with the opportunity to structure the financial arrangements so that the investors can take advantage of these tax benefits. The Congress is now writing the "Tax Reform Act of 1984" which may remove or lessen some of these benefits.

Some of the presently available tax benefits are as follows:

1. An investment tax credit of 10 percent is available on tangible personal property. This investment tax credit is not available for "structural components" of a building. Building systems including boilers, heating, ventilating and air conditioning systems, and other systems which function as a part of the basic building may be considered as structural components by the IRS. There has been considerable controversy as to whether or not energy management systems, which control building heating, ventilating and air conditioning systems, are considered as tangible personal property or a structural component of the building. The IRS has ruled that these are a structural component of the building and therefore

do not qualify for the investment tax credit. To my knowledge, this ruling has not been tested in court.

2. The Accelerated Cost Recovery System (ACRS) method of depreciation is available for items considered as tangible personal property. In most cases, a five year depreciation period is allowed for energy equipment, however, if the equipment is determined to be a structural component of the building, a depreciation period of fifteen years is mandatory. The Senate version of the Tax Reform Act of 1984 would extend the length of the depreciation period for structural components of buildings to twenty years.

3. A 15 percent tax credit is available for solar, wind, hydro, and bio-mass facilities. It is not clear, at this time, whether this credit will be available in its present form when the Tax Reform Act of 1984 is law.

4. In order for investors to obtain the tax credits, they must own the equipment upon which the tax credits are based. Energy service agreements provide that the investors own, maintain and operate the improvement, and enter into a contract to provide a service to the institution. The institution has no ownership or management responsibility. If it desires to own the improvement, it must pay fair market value for the equipment at the end of the contract period. The Tax Reform Act of 1984 will determine if these arrangements will continue to be recognized as service contracts or whether they will be termed leases. If they are leases, investors will not receive the tax benefits. The energy service agreement must be a very carefully structured contract.

5. Many states, including California, have enacted additional tax credits and tax benefits for energy investments. Many of these may be dependent on federal tax law changes and how the federal government views energy service agreements and/or leases for tax purposes.

6. Institutions can issue tax exempt bonds to fund needed improvements. It is also possible for private investors to provide such funding on behalf of tax exempt institutions, without use of the credit of the institution. As this is, in effect, a municipal lease or lease purchase arrangement, tax credits do not apply; the only tax benefit being that of the tax exempt status of the bonds.

Consideration of Alternate Financing

Before energy projects are considered for alternate financing, the following steps should be taken:

1. Develop an overall energy conservation plan for your facility based on a detailed energy audit.

2. Determine needed conservation projects on a priority basis; complete no-cost and low-cost projects.

3. Fund moderate-cost projects internally, or solicit seller financing which is often available for equipment purchases under $100,000. Except

for projects having large tax credit possibilities such as solar, it usually costs less to fund projects internally.

4. Determine if the project or projects are suitable for alternate financing by completing an engineering study of present and future energy consumption. Detailed historical operating data and projections of future needs are a required part of the analysis.

5. Analyze the economics of the project to determine if cost savings will pay off the investment without credit or other risks to the institution.

The Request for Proposal

When a suitable project for alternate financing is identified, it is necessary to structure a process to obtain proposals. Where public money is involved, competitive bidding is normally required. In any case, the institution will want to determine that it is receiving the best available proposal. The following steps were used in the Santa Cruz cogeneration project. A similar process was used for the solar project.

In the spring of 1982, the University of California, Office of the President, placed a nationwide advertisement asking for interest in providing third party financing of cogeneration for any or all of the nine University of California campuses. It was made clear that all costs were to be the responsibility of the developer and that there would be no cost or use of credit on the part of the University. In response to this advertisement, each campus was provided the names of firms interested in providing cogeneration at its campus. For Santa Cruz, there was a list of approximately forty-five firms.

Each of the firms indicating an interest in providing cogeneration at Santa Cruz was issued a Request for Information (RFI). Basic engineering data concerning electrical and heating loads at the campus were provided in the RFI, and interested parties were asked to provide the following: (1) their approach to providing cogeneration for the campus, (2) the financial, engineering and contractual ability of the firm, (3) experience in providing and financing cogeneration systems, and (4) the planned method of financing along with tax considerations.

It is very important to determine the financial ability and experience in designing, constructing, operating and financing of alternate energy projects, of each of the potential developers. This can be done through a pre-qualification procedure whereby firms must submit specific information with only those having adequate finances and experience determined qualified to bid. An alternate method is to allow all interested parties to bid and take the financing and experience component into consideration in evaluating the bids.

A Request for Proposal (RFP) was prepared, which included a "design build" or performance specification for cogeneration systems. General design criteria were specified and performance specifications were provided. The type of system and actual engineering was left to the proposers.

An evaluation procedure must be established and must be fully outlined in the RFP. An evaluation point system was determined with quality points being given for the following:

Rating Criteria	Maximum Quality Points
1. Organizational quality of proposal	10
2. Experience and Qualifications	30
3. Technical Issues	30
4. Management, Financial and Regulatory Issues	30

Economic assumptions, including cost increase projections for utility rates, were provided in the RFP and each proposer was required to submit a cash flow analysis and the present value of cost benefits to the University over a fifteen year period. The proposer having the highest value of cost benefit dollars times quality points was the successful proposer.

Because these projects are new to the institution, extensive negotiations were required with the University counsel and treasurer's offices, the State Department of Finance, and, of course, the developer. A great deal of time was required to obtain all necessary approvals.

Methods of Alternate Financing

Energy service agreements and tax exempt financing of lease purchase agreements are the two basic methods of financing alternate energy projects. We will discuss these methods by reviewing the following projects.

1. Solar installation--micro-utility (energy service agreement).
2. Cogeneration--tax exempt financing (lease purchase agreement).
3. Shared energy savings--energy service agreement.

Micro-Utility - Energy Service Agreement - Solar

The Santa Cruz campus has in operation approximately $750,000 worth of solar collectors which are providing heating for domestic hot water in 38 faculty apartments and 242 student apartments with no capital investment by the University. The thermal energy to heat the water is being provided at a cost less than would have been paid to the utility company and the University will receive $69,700 in utility company rebates over a three year period. The collectors are owned, operated and maintained by the investor, and at the end of five years, these collectors may become the property of the University as a gift from the investors.

In this particular case, a solar collector manufacturer, in order to provide a market for its collectors, established a subsidiary corporation which, as a developer, acts as general partner for a number of limited partnerships. The developer obtains financing to design the systems, purchase and install collectors, leases space from the University, a public agency, and installs and operates the solar collector system in order to sell the thermal energy to the University.

Careful consideration must be given to the disposition of the equipment at the end of the contract period. In the case of the solar collectors at Santa Cruz, the agreement does not specifically state that the campus will receive the collectors because this would make the arrangement a lease, and tax benefits would be lost. The options available to the partnership are to remove the collectors, which is rather unlikely, agree to a continuation of the beneficial heating rate for a second five year period, or, which is probable, donate the collectors and thus receive additional tax benefits at the end of the five year period.

In the case of many cogeneration projects, a similar "micro-utility" is established whereby the developer acts as a utility in selling electricity and heat to the institution. It should be noted that the cogeneration project at Santa Cruz is not a micro-utility, but rather a lease purchase arrangement as described below.

Tax Exempt Financing - Lease Purchase Agreement - Cogeneration

The Santa Cruz campus cogeneration project is an example of tax exempt financing. We have just completed negotiations with the successful developer to provide a 2635 kilowatt cogeneration system with a total cost of $4.32 million. The present value of anticipated excess revenue (beyond cost of operation and debt retirement) from avoidance of energy cost over a fifteen year period is projected to be $3.41 million.

The Santa Cruz cogeneration project will be funded by the developer through tax exempt industrial development bonds which will be issued by the California Alternate Energy Source Financing Authority. This is a State agency specifically established to provide bond financing at tax exempt rates for energy projects. A bank issues a "Letter of Credit" on behalf of the developer to back up the developer's credit. There is no credit exposure to the University; its only obligation is to purchase thermal and electrical energy actually used at rates not exceeding rates it would pay to the local utility company for the same energy.

This is, in effect, a lease purchase arrangement whereby the developer leases land from the University to provide and install a cogeneration system and then leases the system back to the University for its operation. The University, in effect, is purchasing the system through its savings in electrical and gas costs over a ten year period.

In this case, there are no tax investment or energy tax credits which accrue to the developer because the developer is leasing the equipment to the University. The tax saving is to those who invest in the tax exempt bonds.

One might ask, "What is in it for the developer?" The developer, with no capital investment, is receiving funding to construct a cogeneration system and earns, through the process established, profit for design, project management and construction. The profit for the project is being placed in escrow as a part of the bond financing and interest on this investment may accrue to the contractor on a tax exempt basis.

Energy Service Agreement - Shared Energy Savings

We at Santa Cruz have not, as yet, been involved in an energy shared savings project, however, I have obtained information concerning such a project installed at the Delaware Technical and Community College in Georgetown, Delaware. I became aware of this project through an article in the Energy User News issue of Monday, April 23, 1984 and have contacted a staff member at the College. This publication is an excellent source of information on all facets of energy use and is especially helpful in providing up-to-date information on recent legislation as well as information on the financing of energy projects.

The Delaware Technical and Community College entered into a $300,000 energy service agreement for shared savings with a developer. The project is expected to reduce energy costs some 30 percent annually and save more than $100,000 per year in combined fuel and electricity costs.

The developer will replace an old boiler with a new, efficient boiler, provide energy conservation improvements in a number of campus buildings, and will install an energy management system. Some relamping and upgrading modifications of heating, ventilating and air conditioning systems are also included.

Under the terms of the agreement, the developer will provide funding for the entire project and is the owner of the equipment. The developer will share energy savings with the college over the next ten years. The college will keep 15 percent of the savings in the first year, receiving a larger portion of the savings each year to the point of retaining 35 percent of the savings in the tenth year.

Even though the percent of savings to the college in the early years is small, the school still benefits in a material way from the installation of a new boiler, an energy management system, and upgrading of energy use systems, without capital investment. Typically, energy service agreements for shared savings are from seven to twelve years, and the savings split varies from fifty-fifty to 30 percent for the institution, 70 percent for the developer.

For shared savings, investors either through limited partnership, syndication, or direct investment, provide the capital costs and enter into an energy service agreement with the institution. Care should be taken to ascertain the tax benefits planned by the investors. If it appears that the deal depends on dubious tax benefits, the project could fail when investors realize they will not receive these benefits. While it might be difficult for the investors to remove improvements or equipment provided, the IRS could place a lien on such equipment. There could be some very difficult litigation and possible loss to the institution if the proposals are not financially sound. Careful analysis of all tax considerations should be made by the institution before entering into any third party financing agreement.

A paper concerning the Delaware project, written by Barbara Ridgely, College Administrator, and Robert Bartly of the Delaware State Energy Office, concludes with the following statement:

> Overall, the most important factor in the successful writing and signing of a shared savings contract is getting people involved who want to see it work. There are risks that must be taken on both sides, but the

22

financial rewards can make it worth the time and effort.

Summary

Alternate financing is an exciting and positive way of obtaining capital for needed improvements from non-institutional sources. There are always risks involved and while these risks are borne primarily by the developer and investors, there are still risks to the institution if for some reason these projects should fail. Risks include (1) incorrect projections of fuel availability and cost fluctuations over a long period, (2) non-performance by developer, (3) construction cost overruns, (4) regulatory difficulties, (5) financial failure of the developer, and (6) adverse tax rulings which affect investors.

In both the solar and cogeneration projects considered at Santa Cruz, our analysis indicated that the risk was well worth taking and that we have an excellent chance of benefitting from these projects to a greater extent than that projected at this time.

To summarize, if there is a capital improvement, retrofit, or major maintenance project required, and if an income stream from normal operating revenues can be identified, alternate financing should be considered.

As a reference, I suggest Coopers and Lybrand, Innovative Financing for Colleges and Universities. This book may be obtained by writing to:

Mr. Clark Vernard
Coopers and Lybrand
1 Post Office Square
Boston, Massachussetts 02109

The publication provides extensive information on financing of energy-related and other projects.

General Public Utilities has produced a "Catalogue of Innovative Conservation Financing Companies." You can obtain a copy by writing to:

McGlenn Steigner
General Public Utilities
100 Interpace Parkway
Parsippany, New Jersey 07054

Alternate financing can be a great opportunity for us to identify new ways of financing some of the projects we need in a time when we cannot depend on our state governments or governing bodies to provide such financing

An Automated Work Order System for the Small University

By Charles W. Jenkins
St. Mary's University of San Antonio, Texas

Introduction

Someone once said that the format of a presentation meant to impart knowledge should begin with an introduction which outlines the forthcoming contents; follow with the main body wherein the principal points are made and supported; and close with a summary which restates and underscores the main ideas. In other words, tell 'em what you're gonna tell 'em, then tell 'em, then tell'em what you told 'em. This treatise follows that format.

I'll first mention some reasons why you should want to have a system for tracking the work orders done by your staff, and more expressly one which is as foolproof as you can make it. Then I'll tell you about the system we use at St. Mary's University; how we got it, how we use it and what it costs the department to have it. Finally, I'll enumerate the management data which this system affords us and suggest even more diverse uses planned for the future.

Why Automate?

In a letter sent to APPA members last January, George Berry, of the Medical College of Wisconsin, suggests that the excellence of our plant services can be judged by the frequency of complaints which come our way. Few complaints equals good service, etc. I endorse Mr. Berry's premise wholeheartedly. A physical plant department that few people complain about is doing a great job. But, Mr. Director, what about the measure of your individual management expertise? Other than basking in the glow of the wonderful accomplishments of your staff, what can you point to as your own personal contribution to the department? I suggest that the single most important responsibility of the Physical Plant director today is to maximize departmental efficiency - to assure maximum return on every dollar budgeted for and spent in physical plant endeavors. An automated tracking system for your department's work effort can help you do that - and prove it.

Most of us are directly supervised by the university's chief fiscal officer. In my case he's the Vice President for Financial Administration. He's interested, usually intensely so, in where every university dollar goes. He appreciates and respects people who can account for the resources entrusted to their stewardship. So, the most important benefit of our automated work order system, at least from my point of view, is its ability to account for the majority of the department's resource outlay. It tells me where the bucks went and for whom and by whom they were spent. I can show in black and white how many of my plant dollars were converted to useful products.

At the same time, the work order system provides workload data which helps me justify staffing levels. Many critics who are not fazed by your mentioning broad general requirements will leap to your support when confronted with hard data like number of work orders completed, man-hours expended, etc. This data is in the computer, ready for me to call it forth when needed.

Another benefit of our system is that we can track requests for our service from receipt to completion. You all know of the physical plant crack that requests for service sometimes fall through. At St. Mary's we had a physical plant chasm. Now the only time a request falls through the crack is when some human fails to enter it in the automated system. Our computer simply doesn't forget things.

By analyzing historical data from our automated work order files we can see if we're making a fair distribution of our services. You may have, and we've had, squeaking wheel customers who demanded, and got, far more than their share of our resources while others with facility problems stoically endured their burden in silence. Automated records will highlight squeaking wheels in a second. You can also spot installed systems which are chronic problems and maybe ought to be replaced.

The benefits of having this automated file go on and on, but they all add up to helping you be a better manager. So, assuming that your attention is now tweaked, let's discuss how we build automated files at St. Mary's.

St. Mary's University of San Antonio, Texas

Let me digress for a moment, though, and tell you about the St. Mary's campus. Some 25 main buildings on 120 acres comprise the real property on and in which 3,300 students and 500 faculty and staff pursue the goal of higher education. A central hot and chilled water plant serves 16 of the facilities. The physical plant maintenance staff numbers 26 and the housekeepers 36. What we can't do with our assigned staff we contract out to local firms.

The Source Document

Except for recurring duties like grounds maintenance and housekeeping we try to account for everything we do on a physical plant work order. A work order can be generated by a telephonic or written request from a customer or by a physical plant employee who identifies a requirement. Most work order documents are written by the lone departmental secretary, and she does a quality control check on all those written by others. When contractor services are used she prepares a work order, after the fact, to account for that event.

The work order form is a pre-printed, three part IBM paper document, each triplicate form having a control number. Figure One shows the form and labels each of the three copies as to its role in the accounting system. When a work order is first written, the following information is entered: date of request, responsible shop, location of work, customer to be charged, requestor's name and what is to be done.

Copy 3, colored pink, is immediately pulled and put in a suspense file. Copies 1 (white) and 2 (yellow) are given to the responsible craftsperson for completion of the work. When the work is done the craftsperson completes the form by entering action taken, the man-hours expended, the cost of materials used and the date. Copy 2 is then given to the requestor if he or she is available, or sent through campus mail if not. Thus, the communication loop to the requestor is closed.

Copy 1 is returned to the physical plant office by the craftsperson and placed in a completed file. He's now finished with his part of the action, but much remains to be done with Copy 1.

Figure 2 synopsizes the aforementioned routing in diagram form. This diagram is required reading for every newly-hired maintenance person.

The Pre-Automation Fire Drill

Before we automated, all work order accounting was done manually. There were many pitfalls in that scheme. Often, work orders simply wouldn't be written. The worst result of that was that the requirement would be forgotten (the chasm). The best that happened was that the work would be done but no record of it would exist.

When a document was completed and turned in the pertinent data was extracted and entered manually in a logbook. Three work-study students massaged the logbooks daily. The secretary then did nothing for the first three days of each month but extract data from the logs and add figures so she could send a billing report to the comptroller. There were simply too many holes in that method for it to be considered effective - or efficient. The necessity for a better way was obvious. The answer was to computerize.

The POISE Software

At St. Mary's we use the POISE software system. POISE is the acronym derived from People Oriented Information Systems for Education. It is a series of programs designed specifically for creating and maintaining files of repetitive data. By repetitive I mean that each individual record contains the same discrete types of information as every other record. POISE is made to order for charge accounts, mailing lists or, in our case, physical plant work orders. To use the jargon of the trade, POISE is a "user-friendly" system. You converse with the computer in plain English, and it prompts you to provide the information it needs. To learn to use POISE I went to our campus data automation center and viewed eight video-taped lessons of about 1 1/2 hours duration each. Hands-on participation was required and a terminal was set up for that purpose. After the lessons I went back to my office and in about one week of part time effort, with occasional help from the friendly computer wizards, I had created an automated work order file. I hasten to assure you that I'm not a well-versed computer person. This experience, however, has taught me that you don't need to be a programming expert to use the computer as an invaluable tool.

Furthermore, I'm assured by the St. Mary's computer people that I need not fill this paper with a redundance of computerese, block diagrams and the like in order for you to use it as an aid in building your own work order file. Regardless of the software used at your institution, your computer shop can help you set up and use the file if you'll simply explain to them what data you want in there and what you want to do with it.

So, I suppose the single most important point I can make in this presentation is - don't be afraid to automate. If you fear computers because your American Express account stayed screwed up for a year and a half, forget it. That was the fault of an inattentive accounting clerk and we don't employ people like that in our physical plant departments. You can master this technological monster and make it your servant - and you'll be glad you did.

Creating the Automated File

Using the POISE software, we can instruct our Digital PDP 11/70 computer to create and maintain computerized records which resemble our work order forms. The format of the computerized record is as follows:

Field 1: Work Order Number

Note: In the POISE system Field 1 is designated the "key" field. This means that the contents of Field 1 become the key for identifying the individual record within a file of many. Since the work order number is the only piece of information not subject to duplication on other records, it is the only possible key.

Field 2: Date of request
Field 3: Shop assigned
Field 4: Location of work
Field 5: Customer to be charged
Field 6: Requestor's name
Field 7: Description of work
Field 8: Man-hours expended
Field 9: Cost of materials used
Field 10: Date completed

As each field is reserved the operator is required to tell the machine certain things about the data to be stored in the field. Among them are:

field length (number of spaces to be reserved)
explanation (what is this data called?, e.g., date of request)
report heading (when this data is printed out, what do you want to appear at the head of the column?)
prompt text (when data is being entered, how shall the machine prompt the operator for the data in this field?)

Additionally, several instructions can now be loaded to describe the format for printing the data at a later time. Examples are: money - the data will be preceded by a dollar sign and have two decimal places, date - the data will appear as XX/XX/XX, Social Security number - XXX-XX-XXX.

When all fields have been described the machine automatically computes the length, in number of character positions, of each record. It then asks the operator to designate a maximum number of records to be stored in the file. When the operator provides the requested number the machine computes the amount of disk space required for the file and reserves that space. Records can then be loaded into the file.

You can see that before you sit down at the keyboard to build you file, you must do some homework. You must decide on field lengths, report headings and such ahead of time so you can answer the machine's questions. Once you've gone through the drill a time or two, though, it's a piece of cake thereafter.

We have sufficient disk space to store 1,500 records, or just under one month's worth of work orders. We seldom keep more than the two previous months' records on the disk, however, and transfer the older records to a back-up tape. At the end of each budget year we upload the entire 12 months' data and run an annual report. Then we return the entire year to tape.

Entering the Automated Record

Once the file is created and space reserved on the memory disk, the difficult (a relative term) part is over. Records can be entered into the file by anyone having the slightest aptitude for keyboard operation. We've used work study students exclusively to input our records. It usually takes less than an hour to teach them how to log on the machine, gain access to the file, add new records or update ones which are already entered. Our part-time operator keeps the file current by working on Monday, Wednesday and Friday afternoons from one to four.

She first goes to the control copy file and gathers all the pink copy work orders which have accumulated since her last input session. These are new records for initial entry. Responding to the computer's prompting she enters the appropriate data in fields 1 through 7, which is everything we know prior to completion of the work. There is one exception. In field 10, completion date, she enters 999999. This becomes the identifier for work orders which have been opened but not completed. The usefulness of this will be explained later. As each record is entered she discards the pink copy. The computer can now be used to track the work order so the pink control copy is no longer required.

Next, the operator goes to the completed work order depository and collects the white copies which have been turned in since her last session. Since these records were entered earlier from the pink copy she need only update the data by entering man-hours used, material cost and completion date in fields 8, 9 and 10 respectively. Note that an actual completion date now replaces the 999999 in field 10. Input action is now complete for this record. We then file Copy 1 of the work order for at least two months. After that period we can usually be sure that our automated data is accurate and we won't need to refer back to the source document to resolve questions. Then we discard the white copies.

Producing Management Data from the File

Now we have a computer full of poop about our physical plant work orders. So what? Well, all the exercise we've been through was for naught unless we put the data to use for us. By having the machine sort the data in various ways and/or select out only specified pertinent data (both of which tasks it does with amazing alacrity) a number of useful management reports can be produced. At St. Mary's we use the following:

Incomplete Work Order Report. (Figure 3) The machine is instructed to select out all records having 999999 in field 10. It then sorts these by shop, from earliest request date to most current. This group of records is then printed, one record per line, with each line showing shop, work order number, request date, customer, location, requestor and work description. The listing is produced each Monday and includes requests made through the previous Monday. A copy is given to the appropriate superintendent for follow-up with the craftsmen to find out why the work orders are still open. Thus we find and resurrect those which have fallen through the crack or for which the completed Copy 1 has been lost. We can also home in on any problem with material availability, access to work area or other coordination which is delaying completion and which needs resolution. Where appropriate, the superintendent enters the applicable close-out data on his machine listing and gives it to the keyboard operator on Friday. She uses this source in lieu of Copy 1 to complete the record.

Monthly Customer Billing Report. (Figure 4) The machine is instructed to sort the file by customer, then by work location within customer category, then by work order number within location. It further selects out only those work orders closed out during the month being billed. Using this select file, it prints a listing of completed work orders by customer and location showing what was done, at whose request, where it was done, when it was completed, the cost of labor, cost of material and total cost. Sub-totals are entered for each customer and a monthly grand total is provided.

By noon on the first working day of each month, if all goes well, we're prepared to advise the Comptroller of the amounts owed us by those agencies whom we back-charge for our services. For those who don't reimburse, we still have a record of the value of services provided to them. One copy of the report is separated and sent to the various customers so they, too, can see what we're doing for them. Thus do we account for expended resources. Psychologically, we have made ourselves more visible to the people we serve. This report is the culmination of all the effort spent to create the file. The other reports are spin-offs, but nonetheless valuable in their own right.

Building Maintenance History Report. (Figure 5) The file is sorted by location and all work orders done in a single building during the previous month are printed on a single page (or pages). The report is separated and the information pertinent to each building is placed in that building's jacket file. By reviewing the jacket file we can spot recurring problems, justify major overhaul projects and identify customers who seem prone to frivolous requests.

Dormitory Billing Report. (Figure 6) This truncated version of the Customer Billing Report is provided each month to our Housing Director. It repeats the monthly billing data but addresses only the dormitories, by far our largest reimbursable customer. Since each dorm director manages his/her own maintenance budget, this report gives each of them plus the Housing Director an indication of how well they're doing. Our housing people have applauded this report.

Other reports not yet in use but contemplated are:

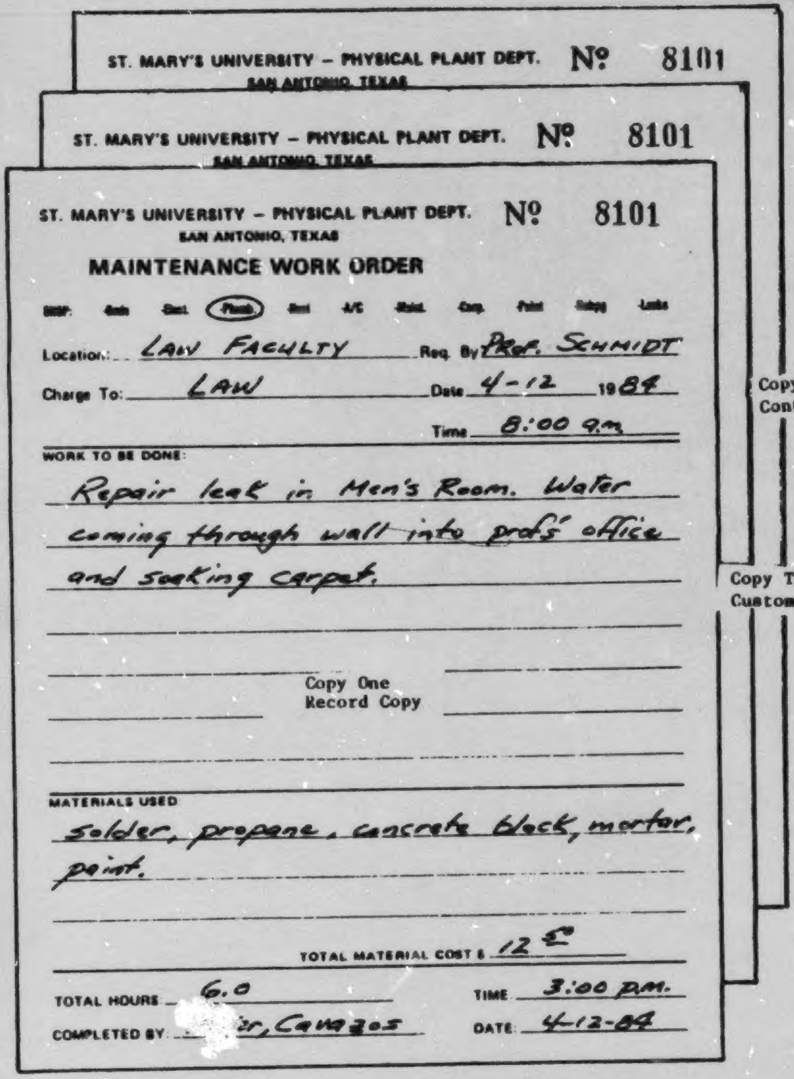
Shop Productivity Report. The machine tabulates the man-hours expended on work orders by each shop for a given time period (usually a month). This figure is then divided by the total number of man-hours available during the same period, the latter data having been gleaned from payroll records. The resulting percentage figure is a measure of the shop productivity. The difference between actual and 100 per cent productivity is lag time of some sort. If lag time seems high, an investigation to isolate causes is in order.

Customer Budget Preparation Report. A report with work orders grouped by customer is run which tabulates the total cost of the previous 12 months' service provided by the physical plant. Budget managers can then use this data as a basis for next year's line item for plant services.

Automotive Maintenance History Report. Only those work orders completed by the automotive shop are selected out and sorted by vehicle identification number. The resulting print-out gives a maintenance history for each assigned vehicle. This data can be used to spot recurring problems and to justify replacement of "garage - queens".

Conclusion

In the preceding text, I've mentioned several advantages which an automated work order system affords the physical plant manager. Further, I've described how the system in use at St. Mary's University was created with only modest effort and how the data is kept current using student labor working part-time. A number of useful management tools were described, each readily available from within the automated work order file. If nothing else accrues from this writing, my earnest hope is that at least one small college physical plant administrator who doesn't now use a computer to track his work orders and who has limited personnel resources to devote to such an effort, will be encouraged to give it a try. Remember, if a klutz like Jenkins can do it, so can you.



ST. MARY'S UNIVERSITY – PHYSICAL PLANT DEPT. № 8101
SAN ANTONIO, TEXAS

MAINTENANCE WORK ORDER

SHOP: Grds. Elect. [✓ Plmb.] [illegible] A/C Maint. Carp. Paint Bldg. Locks

Location: LAW FACULTY Req. By PROF. SCHMIDT

Charge To: LAW Date 4-12 1984

Time 8:00 a.m.

WORK TO BE DONE:

Repair leak in Men's Room. Water coming through wall into profs' office and soaking carpet.

MATERIALS USED

solder, propane, concrete block, mortar, paint.

TOTAL MATERIAL COST $ 12.00

TOTAL HOURS 6.0 TIME 3:00 p.m.

COMPLETED BY [illegible], Cavazos DATE 4-12-84

Copy One
Record Copy

Copy Two
Customer Copy

Copy Three
Control Copy

Figure 1
Physical Plant Work Order

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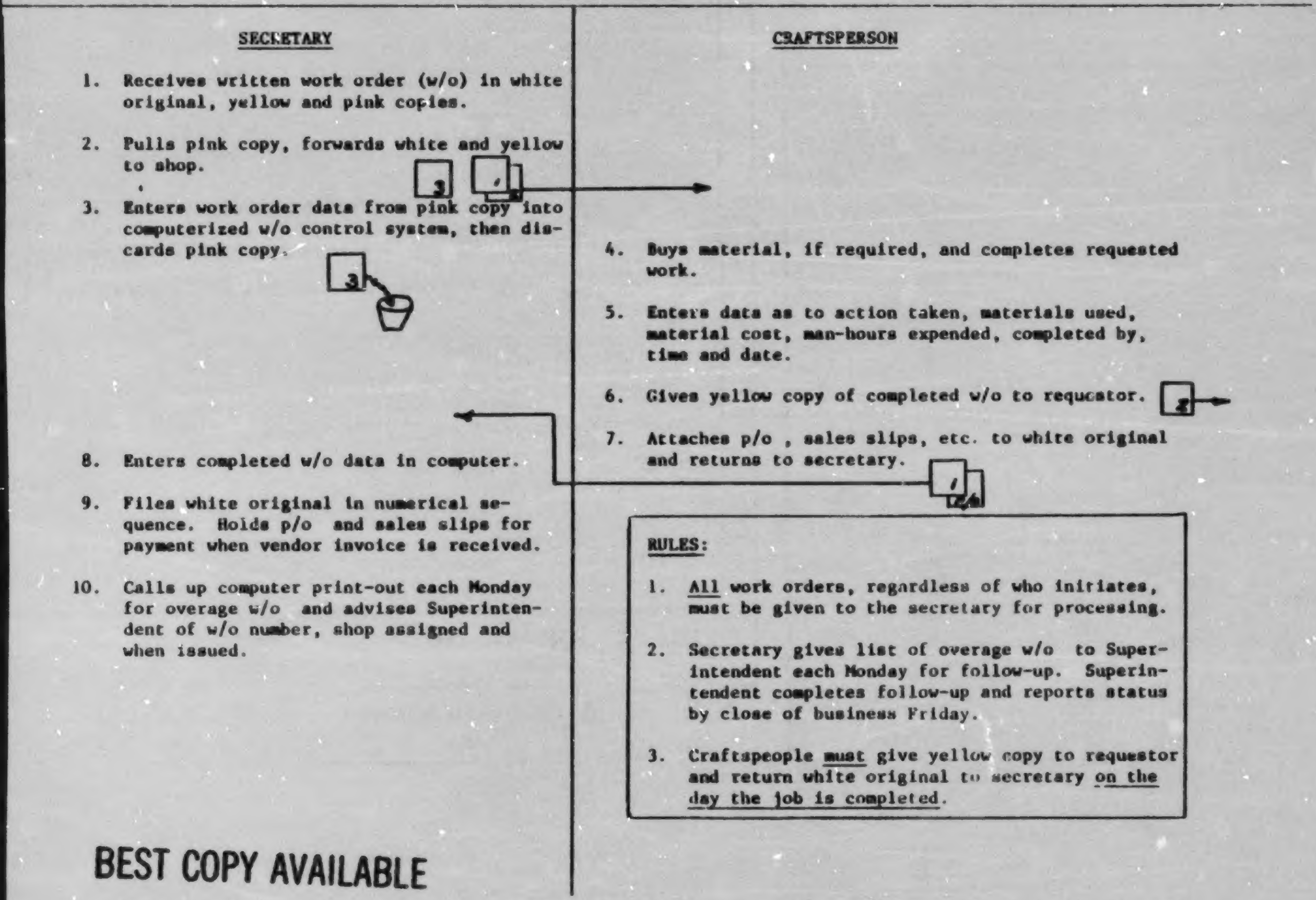
Figure 2

PHYSICAL PLANT WORK ORDER ROUTING



SECRETARY

1. Receives written work order (w/o) in white original, yellow and pink copies.
2. Pulls pink copy, forwards white and yellow to shop.
3. Enters work order data from pink copy into computerized w/o control system, then discards pink copy.
8. Enters completed w/o data in computer.
9. Files white original in numerical sequence. Holds p/o and sales slips for payment when vendor invoice is received.
10. Calls up computer print-out each Monday for overage w/o and advises Superintendent of w/o number, shop assigned and when issued.

CRAFTSPERSON

4. Buys material, if required, and completes requested work.
5. Enters data as to action taken, materials used, material cost, man-hours expended, completed by, time and date.
6. Gives yellow copy of completed w/o to requestor.
7. Attaches p/o, sales slips, etc. to white original and returns to secretary.

RULES:

1. All work orders, regardless of who initiates, must be given to the secretary for processing.
2. Secretary gives list of overage w/o to Superintendent each Monday for follow-up. Superintendent completes follow-up and reports status by close of business Friday.
3. Craftspeople must give yellow copy to requestor and return white original to secretary on the day the job is completed.

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Figure 2

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```
Date 02-May-84
                                    PHYSICAL PLANT
                                 INCOMPLETE WORK ORDERS

SHOP  W/O   REQ DATE LOCATION CUSTOMER REQUESTOR WORK DESCRIPTION
----  ---   -------- -------- -------- --------- ----------------
A/C   6729  04/30/84 TREAD    HSG      MACIAS    A/C NOT COOL IN 3E & 2E
A/C   7894  04/30/84 CHAM H   HSG      WICKER    NO A/C RM 207
A/C   8162  04/30/84 REINBOLT PLANT    RYAN      A/C IN ASSUMPTION CHAPEL NO COOL



CARP  7872  04/18/84 CHAM H   HSG      WICKER    REPAIR BATH DOOR,RM 23
CARP  7034  04/25/84 DOUGHTY  HSG      T.C.      REPAIR DRAWER



ELECT 6729  04/30/84 TREAD    HSG      MACIAS    MORE 100 WATT BULBS 4TH FLOOR



HSKPG 7773  04/23/84 CHAM H   HSG      WICKER    REMOVE BROKEN GLASS
HSKPG 5459  04/26/84 TREAD    ACAD VP  DURA      SET UP BRASS LAMP FOR FAM LIFE
HSKPG 7883  04/26/84 CHAM H   HSG      WICKER    CLEAN 120,20,29,21,118,20
HSKPG 8175  04/30/84 TREAD    CAMP MIN STUDENT   EMPTY TRASH CANS SACRISTY



LOCKS 7895  04/30/84 CHAM H   HSG      WICKER    KEY NEEDED RM 305
LOCKS 8165  04/30/84 REINBOLT ACAD VP  RYAN      CHANGE LOCK IN R-2
LOCKS 5179  04/30/84 GARNI    ACAD VP  FETZER    INSTALL LOCKS RM 122 CABINETS



MAINT 8052  04/23/84 CH FRAN  HSG      BARRY     REPLACE WINDOW #211
MAINT 5097  04/25/84 LIFE SCI ACAD VP  CHENNING  REPAIR SEAT
MAINT 6726  04/27/84 TREAD    HSG      LUCY      REPLACE LIGHTS 2F & LOBBIES
MAINT 7897  04/30/84 CHAM H   HSG      WICKER    INSTALL BLINDS RM 114 314



PAINT 8129  04/27/84 LAW FAC  LAW      BARA      PAINT REDWOOD ABOVE ATRIUM WITH PRESERER



PLUMB 7485  04/19/84 MARIAN   HSG      BARRY     UNCLOG SINK #234
PLUMB 3132  04/27/84 VJ KEEFE ATHL     KOSUR     REPAIR SPRINKLER SYS
PLUMB 6727  04/30/84 TREAD    HSG      MACIAS    SHOWER STOPPED UP
```

FIGURE 3

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```
Date 1 MAY 84
                                                  PHYSICAL PLANT
                                              CUSTOMER BILLING REPORT
                                                    APRIL 1984

CUSTOMER LOCATION W/O   SHOP  REQUESTOR WORK DESCRIPTION                      COMPL DT         LABOR $          MAT $        TOTAL $
-------- -------- ---   ----  --------- ----------------                      --------         -------          -----        -------
ACAD VP  ACAD LIB 7569  MAINT VICKI     REPLACE SPECIAL COLLECTION OF LIGHTS  04/23/84          $13.50        $118.40        $131.90
ACAD VP  ACAD LIB 7782  MAINT VICKI     REPLACE LIGHTS                        04/04/84           $4.50         $19.20         $23.70
ACAD VP  ACAD LIB 7927  MAINT VICKI     REPLACE BURNT BULBS                   04/04/84           $4.50         $28.00         $32.50
ACAD VP  ACAD LIB 7916  CARP  YOLANDA   CHECK PRICE FOR CAGE FOR DEPOSITORY   04/10/84           $4.50                         $4.50
ACAD VP  ACAD LIB 7921  MAINT VICKI     LIGHTS OUT IN MEN'S RESTROOM          04/09/84           $4.50          $5.31          $9.81
ACAD VP  ACAD LIB 7947  MAINT VICKI     REPLACE LIGHT IN TELEPHONE BOOTH      04/11/84           $4.50           $.80          $5.30
ACAD VP  ACAD LIB 7953  MAINT TONY      REPLACE LIGHTS                        04/11/84          $18.00         $64.00         $82.00
ACAD VP  ACAD LIB 7970  CARP  STEWART   BUILD SHELF FOR LRC                   04/13/84          $18.00         $10.00         $28.00
ACAD VP  ACAD LIB 8042  MAINT ANTHONY   CHANGE BULBS, 1ST FLR                 04/18/84           $4.50          $9.60         $14.10
ACAD VP  ACAD LIB 8070  MAINT ANTHONY   REPLACE LIGHTS                        04/24/84           $9.00         $54.40         $63.40
ACAD VP  ACAD LIB 8076  CARP  KATHY     BRACE SHELVES COUNTER BUILD SHELF     04/30/84          $22.50          $5.00         $27.50
ACAD VP  ACAD LIB 8099  MAINT ANTHONY   REPLACE LIGHTS                        04/30/84           $4.50          $4.04          $8.54
                                                                                        -------------- -------------- --------------
                                                                                               $112.50        $318.75        $431.25


ACAD VP  ADMIN    5417  HSKPG CLAIRE    PICK UP BLIND                         04/03/84          $13.50                        $13.50
ACAD VP  ADMIN    5424  HSKPG ROBIN     MOVE DESKS & BOXES                    04/09/84          $67.50                        $67.50
ACAD VP  ADMIN    5425  HSKPG RYAN      MOVE FILE CABINETS                    04/06/84          $27.00                        $27.00
ACAD VP  ADMIN    5427  HSKPG NORMA     MOVE FURNITURE IN UPWARD BOUND OFFICE 04/06/84         $135.00                       $135.00
ACAD VP  ADMIN    5432  HSKPG LETTY     MOVE TABLES & CHAIRS                  04/10/84           $9.00                         $9.00
ACAD VP  ADMIN    5444  HSKPG JACKIE    REMOVE THREE CHAIRS FROM UPWARD BND   04/16/84           $9.00                         $9.00
ACAD VP  ADMIN    5447  HSKPG CLAIRE    DELIVER CHAIRS TO 311 REINBOLT        04/23/84           $9.00                         $9.00
ACAD VP  ADMIN    7646  A/C   HUTSELL   CHECK A/C #303                        04/04/84           $4.50                         $4.50
ACAD VP  ADMIN    7796  HSKPG ISABEL    PICK UP FILE CABINET                  04/02/84           $9.00           $.00          $9.00
ACAD VP  ADMIN    7804  MAINT ISABELL   REPLACE LIGHT IN STORAGE ROOM         04/03/84           $4.50           $.80          $5.30
ACAD VP  ADMIN    7932  MAINT JACKIE    SECURE WINDOW                         04/04/84           $4.50          $4.00          $8.50
ACAD VP  ADMIN    7943  A/C   LETTY     CHECK A/C IN #304                     04/05/84           $4.50                         $4.50
ACAD VP  ADMIN    8012  MAINT MYLER     REPLACE BULB, RM 26                   04/16/84           $4.50          $2.00          $6.50
ACAD VP  ADMIN    8082  CARP  RYAN      REPAIR CHAIR                          04/25/84           $9.00                         $9.00
ACAD VP  ADMIN    8169  MAINT DORA      REPLACE HALL LIGHT                    04/30/84           $4.50                         $4.50
                                                                                        -------------- -------------- --------------
                                                                                               $315.00          $6.80        $321.80


ACAD VP  ALKEK    5419  HSKPG ROBIN     DELIVER TABLE                         04/05/84           $9.00                         $9.00
                                                                                        -------------- -------------- --------------
                                                                                                 $9.00           $.00          $9.00


ACAD VP  CH FRAN  7760  LOCKS LEIES     CHANGE LOCK TO ART DEPT               04/16/84           $9.00                         $9.00
ACAD VP  CH FRAN  8063  A/C   CHUCK     PEAK UP ART DEPT A/C                  04/25/84          $36.00                        $36.00
                                                                                        -------------- -------------- --------------
                                                                                                $45.00           $.00         $45.00


ACAD VP  GARNI    7952  PLUMB CUMM      CHECK PRESSURE IN WATER COOLER        04/09/84           $4.50                         $4.50
ACAD VP  GARNI    7965  MAINT CUMM      REPLACE LIGHTS                        04/06/84           $4.50          $5.00          $9.50
ACAD VP  GARNI    7989  PLUMB BRU CHAS  REPAIR WATER COOLER                   04/13/84           $9.00                         $9.00
```

26

FIGURE 4

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Date 02-May-84

PHYSICAL PLANT
BUILDING HISTORY REPORT
APRIL 1984

LOCATION	CUSTOMER	W/O	COMPL DT	SHOP	REQUESTOR	WORK DESCRIPTION	LABOR $	MAT $	TOTAL $
ADMIN	ACAD VP	5410	04/03/84	HSKPG	CLAIRE	PICK UP BLIND	$13.50		$13.50
ADMIN	ACAD VP	5424	04/09/84	HSKPG	ROBIN	MOVE DESKS & BOXES	$67.50		$67.50
ADMIN	ACAD VP	5425	04/06/84	HSKPG	RYAN	MOVE FILE CABINETS	$27.00		$27.00
ADMIN	ACAD VP	5427	04/06/84	HSKPG	NORMA	MOVE FURNITURE IN UPWARD BOUND OFFICE	$135.00		$135.00
ADMIN	ACAD VP	5432	04/10/84	HSKPG	LETTY	MOVE TABLES & CHAIRS	$9.00		$9.00
ADMIN	ACAD VP	5444	04/16/84	HSKPG	JACKIE	REMOVE THREE CHAIRS FROM UPWARD BND	$9.00		$9.00
ADMIN	ACAD VP	5447	04/23/84	HSKPG	CLAIRE	DELIVER CHAIRS TO 311 REINBOLT	$9.00		$9.00
ADMIN	ACAD VP	7646	04/04/84	A/C	HUTSELL	CHECK A/C #303	$4.50		$4.50
ADMIN	ACAD VP	7796	04/02/84	HSKPG	ISABEL	PICK UP FILE CABINET	$9.00	$.00	$9.00
ADMIN	ACAD VP	7804	04/03/84	MAINT	ISABELL	REPLACE LIGHT IN STORAGE ROOM	$4.50	$.80	$5.30
ADMIN	ACAD VP	7932	04/04/84	MAINT	JACKIE	SECURE WINDOW	$4.50	$4.00	$8.50
ADMIN	ACAD VP	7943	04/05/84	A/C	LETTY	CHECK A/C IN #304	$4.50		$4.50
ADMIN	ACAD VP	8012	04/16/84	MAINT	MYLER	REPLACE BULB, RM 26	$4.50	$2.00	$6.50
ADMIN	ACAD VP	8082	04/25/84	CARP	RYAN	REPAIR CHAIR	$9.00		$9.00
ADMIN	ACAD VP	8168	04/30/84	MAINT	DORA	REPLACE HALL LIGHT	$4.50		$4.50
ADMIN	DEVEL	4191	04/07/84	A/C	HUBER	A/C OUT, 211, 216	$18.00		$18.00
ADMIN	DEVEL	7789	04/02/84	CARP	MELISSA	CUT STAKES	$4.50	$.00	$4.50
ADMIN	DEVEL	7826	04/05/84	HSKPG	MELISSA	DELIVER CHAIRS,TABLES,BOARDS	$9.00	$.00	$9.00
ADMIN	DEVEL	7933	04/10/84	CARP	MELISSA	FASTEN SIGNS TO STAKES	$4.50		$4.50
ADMIN	DEVEL	8072	04/24/84	A/C	MABEL	REPAIR WINDOW UNIT	$4.50		$4.50
ADMIN	FIN VP	5434	04/10/84	HSKPG	TOMMIE	DELIVER CHAIRS	$9.00		$9.00
ADMIN	FIN VP	7941	04/05/84	MAINT	TONY	CHANGE BALLAST	$9.00	$17.07	$26.07
ADMIN	FIN VP	7944	04/11/84	CARP	TONY	PLEASE FIX DRAWER	$9.00		$9.00
ADMIN	FIN VP	7964	04/09/84	PAINT	JENKINS	PAINT RM 213	$144.00	$36.00	$180.00
ADMIN	FIN VP	8015	04/23/84	ELECT	ELENA	REPLACE LIGHT FIXTURES	$27.00	$135.00	$162.00
ADMIN	FIN VP	8057	04/24/84	CARP	KUSAR	MAKE BOARD FOR DESK	$9.00		$9.00
ADMIN	LAW	5456	04/24/84	HSKPG	SOPHIE	DELIVER REAMS OF PAPER	$9.00		$9.00
ADMIN	PLANT	7726	04/02/84	PLUMB	RYAN	CHECK FOR SOURCE OF WATER	$9.00	$10.00	$19.00
ADMIN	PLANT	7929	04/09/84	MAINT	KUSAR	REPAIR WATER FOUNTAIN	$4.50	$5.00	$9.50
ADMIN	PLANT	7977	04/12/84	CARP	KATHY	REHANG PICTURE	$4.50		$4.50
ADMIN	PLANT	7992	04/12/84	ELECT	MARK	INSTALL NEW PORCH LIGHTS, N END	$13.50	$200.00	$213.50
ADMIN	PLANT	8017	04/17/84	MAINT	JENKINS	CLEAN METAL DOOR FRAMES	$22.50		$22.50
ADMIN	PLANT	8033	04/17/84	ELECT	MARK	REPLACE PORCH LIGHT FIXTURES	$9.00	$200.00	$209.00
ADMIN	PLANT	8049	04/19/84	ELECT	CLAIRE	TURN OFF OUTSIDE FLOOD LIGHTS	$4.50		$4.50
ADMIN	PLANT	8087	04/25/84	PLUMB	RYAN	CHECK LEAK IN LADIES RESTROOM	$4.50		$4.50
ADMIN	PRES	5445	04/16/84	HSKPG	JENKINS	SHAMPOO CARPET IN PRES SUITE	$13.50		$13.50
ADMIN	PRES	7326	04/01/84	HSKPG	BEA	REMOVE BROKEN CHAIRS FROM FIN AID OFC	$4.50		$4.50
ADMIN	PRES	7959	04/06/84	MAINT	MARGARET	REPLACE LIGHTS IN FINANCIAL AIDE OFFICE	$1.90	$6.00	$7.90
ADMIN	PRES	7976	04/06/84	A/C	MELBA	A/C UNIT INOP	$18.00		$18.00
ADMIN	SCH BUS	5421	04/05/84	HSKPG	CLASEN	DELIVER CASES OF PAPER	$4.50		$4.50
ADMIN	SCH BUS	5448	04/17/84	HSKPG	YOLANDA	DELIVER PAPER TO ALKEK	$18.00		$18.00
							$703.80	$615.87	$1,319.67

FIGURE 5

DATE= 1 MAY 84

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PHYSICAL PLANT BILLING REPORT
DORMITORIES ONLY
APRIL 1984

LOCATION	W/O	SHOP	REQUESTOR	WORK DESCRIPTION	COMPL DT	LABOR $	MAT $	TOTAL $
CHAM H	7492	A/C	BARRY	CHECK A/C IN #32 & #34	04/02/84	$13.50		$13.50
CHAM H	7612	A/C	WICKER	REPAIR A/C #311,217	04/04/84	$9.00		$9.00
CHAM H	7625	PLUMB	WICKER	UNCLOG SHOWER #26	04/06/84	$4.50		$4.50
CHAM H	7626	PLUMB	WICKER	REPAIR SHOWER #109 & #314	04/11/84	$27.00	$37.00	$64.00
CHAM H	7722	A/C	WICKER	CHECK A/C IN #30,314	04/02/84	$22.50		$22.50
CHAM H	7724	LOCKS	WICKER	CHECK LOCK TO BACK ENTRANCE DOOR	04/04/84	$22.50	$90.00	$112.50
CHAM H	7727	A/C	WICKER	CHECK A/C IN #132,311	04/04/84	$22.50	$6.00	$28.50
CHAM H	7728	PLUMB	WICKER	CHECK SHOWERS IN #17,18,19	04/03/84	$9.00	$36.00	$45.00
CHAM H	7729	LOCKS	WICKER	KEY NEEDED FOR #219	04/04/84	$4.50		$4.50
CHAM H	7730	CARP	WICKER	REPAIR DOOR	04/03/84	$72.00	$90.00	$162.00
CHAM H	7731	PLUMB	WICKER	REPAIR FOUNTAIN ON 3RD FLOOR	04/04/84	$4.50	$.00	$4.50
CHAM H	7732	A/C	WICKER	CHECK A/C IN #205	04/12/84	$4.50		$4.50
CHAM H	7734	A/C	WICKER	CHECK A/C IN #131,317	04/04/84	$22.50	$55.00	$77.50
CHAM H	7738	PLUMB	WICKER	CHECK SHOWER IN #219	04/03/84	$9.00	$5.00	$14.00
CHAM H	7741	MAINT	WICKER	REPLACE BURNT OUT LIGHTS IN HALLWAY	04/03/84	$4.50	$4.00	$8.50
CHAM H	7746	PLUMB	WICKER	UNCLOG BATHTUB	04/05/84	$9.00		$9.00
CHAM H	7747	MAINT	WICKER	REPLACE TOILET PAPER HOLDER	04/05/84	$4.50		$4.50
CHAM H	7748	ELECT	WICKER	REPAIR LIGHT SWITCH	04/09/84	$4.50	$3.00	$7.50
CHAM H	7750	HSKPG	WICKER	CLEAN TOPS OF WASHERS	04/05/84	$4.50		$4.50
CHAM H	7752	CARP	WICKER	REPAIR TABLE IN LAUNDRY ROOM	04/04/84	$18.00	$.00	$18.00
CHAM H	7754	LOCKS	WICKER	CHECK LOCK #21 & #27	04/09/84	$13.50		$13.50
CHAM H	7758	MAINT	WICKER	REPLACE LIGHT SWITCH	04/10/84	$4.50		$4.50
CHAM H	7759	ELECT	WICKER	REPAIR LIGHT SWITCH ON 3RD FLOOR	04/10/84	$4.50		$4.50
CHAM H	7761	MAINT	WICKER	REPAIR FOUNTAIN	04/10/84	$13.50	$8.00	$21.50
CHAM H	7762	A/C	WICKER	CHECK A/C #131	04/10/84	$9.00		$9.00
CHAM H	7763	LOCKS	WICKER	REPAIR LOCK #131	04/09/84	$4.50		$4.50
CHAM H	7764	PLUMB	WICKER	REPAIR LEAKING FAUCET	04/11/84	$4.50	$12.00	$16.50
CHAM H	7765	MAINT	WICKER	REPAIR LOCK ON REAR ENTRANCE	04/19/84	$4.50		$4.50
CHAM H	7769	A/C	WICKER	CHECK A/C LEAKS IN #114,131,LAUNDRY	04/24/84	$9.00		$9.00
CHAM H	7770	LOCKS	WICKER	KEY NEEDED RM#303	04/25/84	$4.50		$4.50
CHAM H	7772	GNDS	WICKER	CLEAN UP TRASH	04/25/84	$.00		$.00
CHAM H	7774	MAINT	WICKER	REPLACE LIGHT IN SNACK RM	04/27/84	$4.50	$2.00	$6.50
CHAM H	7775	PAINT	WICKER	PAINT DOOR, 318	04/23/84	$72.00	$12.00	$84.00
CHAM H	7776	MAINT	WICKER	REPLACE DOOR KNOB, 122	04/19/84	$9.00	$40.00	$49.00
CHAM H	7810	MAINT	WICKER	REPLACE WINDOWS	04/24/84	$9.00	$13.92	$22.92
CHAM H	7817		WICKER	REPLACE GLASS BY CONTRACT	04/12/84	$.00	$81.54	$81.54
CHAM H	7822		CONTRACT	GUADALUPE LUMBER BY CONTRACT	04/13/84	$.00	$61.90	$61.90
CHAM H	7868	MAINT	WICKER	SHOWER CLOGGED, 318	04/19/84	$4.50	$5.00	$9.50
CHAM H	7869	MAINT	WICKER	FIX OUTLET COVER, RM 112	04/19/84	$4.50	$1.00	$5.50
CHAM H	7870	MAINT	WICKER	REPLACE SHOWERHEAD, RM 101	04/19/84	$4.50	$4.00	$8.50
CHAM H	7871	LOCKS	WICKER	CUT KEY FOR 210	04/19/84	$4.50		$4.50
CHAM H	7874	MAINT	WICKER	REPLACE NUMEROUS SWITCH COVERS	04/19/84	$4.50	$3.00	$7.50
CHAM H	7876	LOCKS	WICKER	CUT KEYS FOR 210,203	04/19/84	$4.50		$4.50
CHAM H	7881	LOCKS	WICKER	RM 125 RM 303 STICKY LOCKS	04/30/84	$9.00		$9.00
CHAM H	7882	HSKPG	WICKER	CLEAN BATHTUB IN LOBBY, ETC	04/25/84	$9.00		$9.00
CHAM H	7890	PLUMB	WICKER	LEAKY FAUCET, RM 307	04/26/84	$18.00	$32.00	$50.00
CHAM H	9067	HSKPG	WICKER	PICK UP DISCARDED CARPET	04/23/84	$9.00		$9.00
CHAM H	9088	MAINT	BRYANT	UNCLOG SHOWER #331	04/25/84	$9.00	$5.00	$14.00
						$540.00	$607.36	$1,147.36

FIGURE 6

Informing The Customer

By James T. Mergner, P.E.
University of Virginia

Introduction

Keeping the customer informed is an essential attribute of a responsive physical plant department. One aspect of this is to provide the university or college community with information on those projects in which they have a particular interest. This capability can be easily developed with a small investment in computer hardware, software, and of course, your efforts to describe your new information system.

In relating what we have been able to accomplish at the University of Virginia, I will show you an easy way to improve the flow of information on project status to your customers. An added benefit of our efforts is the increased ability to keep track of the work in our system. These benefits all are gained through the use of the microcomputer.

In the spring of 1982, we began developing an information system which would:

a. Provide easily understood monthly status reports to all physical plant customers listing those projects in which they have a particular interest; and,

b. Provide a means for the internal tracking of the approximately 400 projects in the physical plant system, each at a different stage of development.

As background information, the University of Virginia's physical plant includes 547 buildings with a total of 8.4 million square feet of space located in Charlottesville, Virginia. Our buildings include considerable space for academic and research endeavors and a tertiary care teaching hospital. The Department of Physical Plant is staffed with approximately 640 employees performing facilities planning, design services, maintenance, renovations, housekeeping, and utilities services.

The projects we wanted to monitor and for which reports would be distributed included renovations of existing facilities, major maintenance projects, and customer funded minor work. The renovation projects support the academic programs, research endeavors, and medical care, all ongoing in our community. Major maintenance projects such as roofing system replacements, interior and exterior painting and mechanical system repairs, and customer funded minor work such as the installation of shelving, signage, and new electrical outlets, are all of interest to our customers.

Various means of developing this new system were reviewed and the choices narrowed to the following three:

a. Obtain systems development, programming and computer services from the university's administrative computing services.

b. Purchase a microcomputer and a software package to be adapted for this particular need.

c. Purchase a microcomputer and develop specific application programs.

With the encouragement of our then Executive Vice President, Avery Catlin, who as a faculty member teaches computing, we chose to purchase a microcomputer and develop our own application programs. This appeared to be the quickest and least expensive way to obtain the desired reporting system structured to accomodate our specific needs.

Once this decision was made, our efforts were directed to choosing the hardware and software needed to complete the project. Our academic computing services recommended the Northstar Advantage Microcomputer for word processing and other microcomputer applications. We accepted their advice and purchased a Northstar Advantage. For the application language, Mr. Catlin suggested using dBASE II, an assembly-language relational database management system. This computer language was needed to develop and execute the application programs we would require for this system. Lastly, the Financial Aid office was able to locate a student with programming experience who was available for part-time employment. With an initial investment of less then $4,000, we were ready to proceed with the actual development and implementation of our own reporting system.

Project Tracking System

In developing the system, it was necessary to determine what information would be tracked for the various projects, design the formats for presenting this information, establish a procedure for periodic updating of the data, decide who would benefit from receiving periodic reports of project status, determine the frequency at which reports would be distributed and, lastly, assign responsibility for development and operation of the system.

The prime prerequisite of the project tracking system was that the information presented would be easily read and understood by a person not familiar with the physical plant function. Reports would be presented in a clear and concise format with a tailored distribution system minimizing the size of each printout.

The format chosen is displayed in Figure I. In this format, the information has been divided into three groups. The first group is descriptive information identifying the particular project. This includes the project's work order number, title, requestor, request date, and location.

The second group of information includes the name of the person within the physical plant organization who is responsible for the project at its particular stage of development. Projects requiring design by our Architectural and Engineering Services prior to accomplishment of work are assigned a project manager for the life of the project. When the project begins its construction phase, the construction supervisor is identified in our tracking system.

For each project, a planned schedule is developed based on preestablished milestones which are typical for each project. The anticipated completion dates for these milestones are listed. As each milestone is reached, its actual completion date is recorded allowing a comparison of actual time required to accomplish each phase of the project development with the planned schedule.

The third group of information displayed includes the current budget, the construction completion percentage and comments further describing the status of the project. Since updating information is entered periodically, the date of the last update is displayed.

An important feature of the project tracking system is the automated distribution system which is designed to ensure that project status information is provided to those individuals who have a need for it on projects impacting upon their area of interest. This system is structured to generate reports to four levels of distribution within the university community. At the first level, each of the five vice presidents receives a report for those projects within his overall area of responsibility. At the second level of distribution, the deans and department heads receive reports for only those projects within their area of responsibility and, at the third level, the chairmen and division heads receive their reports. Theoretically, each project in the system will be reported to three levels within the hierarchy of the university. The fourth level of distribution is a specially structured system generating reports to accommodate the specific needs of various individuals not addressed by the three levels previously described. Fortunately, the computer allows us to print the complete distribution package without intervention by the operator.

In order for the reporting system to be effective, it is essential that the information that is reported be current. To accomplish this, automated sequences have been developed to generate updating packages for distribution to the appropriate project manager or construction supervisor listed for each project. Those projects that are in the initial investigation or design phase are printed and distributed to the project managers on a biweekly basis. After annotating the reports with the latest status, they are returned for data entry. Projects in the construction phase are distributed on a weekly basis to the construction supervisor listed to be annotated with the latest data and returned for data entry. Under this procedure, the persons receiving packages for updating purposes are not burdened with long listings of projects, but rather are provided listings of only those projects for which they have responsibility for development.

We have a formal priority system to identify and monitor those projects requiring expedited development. These projects are identified by a priority A or B in our system and receive a higher level of management attention. In lieu of our routine updating for these projects, a weekly coordination meeting is held with the representatives of the various areas within physical plant in attendance. This is done to ensure that progress continues on each priority project and, at this meeting, the status is ascertained for entry into the tracking system. A weekly report listing the status of the priority and special interest projects is distributed to the appropriate upper level physical plant managers for their continuing action.

In order to keep the managers appraised of the overall status of projects within their area of responsibility, monthly reports are distributed to the University Architect, Medical Center Architect, and the Assistant Director of Engineering Services listing those projects assigned to individuals within their respective areas. These reports are generated at the fourth level of distribution previously described.

An additional use of the information stored is that a particular project can be displayed on the computer's screen to quickly determine the latest status reported by the project manager or construction supervisor.

Distribution System

In developing the customized distribution mechanism for the tracking system, it was of utmost importance to insure that only information on projects which the recipient had a particular interest would be provided. This was accomplished by coding each project with three separate identifiers each relating to a different tier of the university's organization. The first identifier relates the project to the vice president responsible for the area requesting the project. This identifier is assigned within the programming and not reported by the system. The second identifier, known as "administrative unit," relates to the dean or department head requesting the project. The third identifier, known as "department," relates to the chairman or division head requesting the project. This coding system is designed to parallel organizational structure of the University of Virginia.

The name and address of the responsible party for each unique identifier is stored in a data file separate from the project data file. An example of the information stored is displayed in Figure 2. Having these two related files, it is possible to prepare a status report, addressed to an individual, which includes information only for those projects in which that person has a particular interest. This procedure was not difficult to program and it is one of the more important attributes of our project tracking system.

All routine distribution of information on the projects in the tracking system is accomplished using preestablished formats and schedules. This relieves the system operator from having to remember to print reports and distribute them. Special reports to suit specific needs can be easily produced by the system operator in a very timely fashion.

Implementation

The Work Management Division is responsible for work reception and work control for the department. This made it a logical choice to be assigned the responsibility for developing the project tracking system and the continuing responsibility for its operation. Initial entry of a project into the system is accomplished by Work Management upon its receipt and monitoring continues throughout the entire life of the project. We chose to place the first microcomputer at our service call desk. This allowed us to have the person receiving the service calls to operate the computer during slack periods. As the implementation of this system expanded, a second microcomputer was added and placed at an existing work station. To recognize the additional duties, both positions have been reclassified as information processing specialists. In this way, we now have two equally qualified persons to operate the project tracking system in addition to performing the duties that existed prior to implementation of our information system.

The two main purposes of the project tracking system are to provide information to our customers in a format that is easily read and understood and to have a system to monitor the development of projects within the physical plant. This system has been well received by our customers and has generated many favorable comments. There has been a noticable decrease in the number of telephone inquiries concerning the status of particular projects. Rarely do our customers complain of hearing nothing of a project that they have sent to physical plant for development. Also, our efforts to develop projects are better monitored and are done in a more orderly fashion.

Several benefits have resulted from the project tracking system that were not anticipated at the time the decision was made to proceed with its development. One benefit is being able to prepare mailing labels for distribution of such materials as our services bulletins and other mailings to the university and medical center community. Also, we have developed an automated listing of facilities coordinators as part of the system development that was done for our automated distribution system.

Having project information stored in an automated system allows us to develop statistical information on the performance of the department. The statistical summary allows us to track the number of projects in design, under construction, and completed each month by the department. We also can track these statistics from month to month. This provides us with another indicator of the quality of service provided by our department.

Implementation of this system has not been entirely trouble free. There have been difficulties in obtaining timely updating by the project managers and the construction supervisors. Also, the quality of the information provided continues to require management attention. Fortunately, these problems are diminishing with system acceptance and recognition of the project tracking system's value as a management tool.

Conclusion

Our adventure into the world of automation to develop the project tracking system has provided the impetus to automate a number of other areas within our department. A complete system for monitoring and reporting the status of capital outlay projects has been developed. We also have developed systems to track material orders, utilities consumption and billing, and a personnel listing of all physical plant employees. As our dependence on the microcomputer expanded, it became necessary to add a computer programmer to our staff. This allows us to continue our system development in a more professional fashion, trouble-shoot problems that occur, and plan for our next generation information system. As managers have been able to observe the benefits of automation, the number of microcomputers in use within our department has increased to fourteen with more to be added as the needs develop.

Our direction for the future is to bring together the various information systems mentioned on a single computer with multiple terminal access to the information stored. Although additional programming will be necessary, all the efforts to design and implement the individual in-place systems will be very useful in developing our next generation information system. Our long range goal is to have a fully integrated information and cost accounting system addressing the needs of all segments of the physical plant organization.

I have deliberately avoided any efforts to encourage you to purchase any particular computer or software. There are many vendors all willing to describe the merits of their products to you. Rather, my efforts are all aimed at showing you how you can improve your customer relations by the use of the computer.

While I have been describing our project tracking system, I hope that you have been thinking of ways that you can enjoy the fruits of automation in your department. We have found that the development of automated systems in support of the physical plant function has been successful and the rewards have been many. The project tracking system plays a key role in our overall responsibility of informing the customer.

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                  HCLS/SLEEP DISORDERS LAB

   DESIGN W.O. NUMBER: 72238                           ALT. ID: 072238
   CONSTRUCTION W.O. NUMBER: 92238                     ADM. UNIT: HCLS
   PRIORITY: A                                         DEPARTMENT: INMD
   REQUESTOR: Surratt                                  BLDG/RM: 174/B426 TO B437
   REQUEST DATE: MAY 20 1983                           CONSULTANT:
   ORIGINAL BUDGET: $   75.000                          John Farmer
=============================================================================
  HOSPITAL ADM.:   HINSDALE    924-0437
  PROJECT MANAGER:                                 CONSTRUCTION SUPERVISOR:
     ATWOOD       924-3718                             SHIFLETT    924-7771

                                     PLANNED       CURRENT       ACTUAL
  PROJECT PROGRAM                  -----------   -----------   -----------
  PROGRAM APPROVAL                 NOV  7 1983   -----------   DEC  9 1983
  SCHEMATIC DRAWINGS               NOV  7 1983   -----------   DEC  9 1983
  PRELIMINARY DRAWINGS             DEC 20 1983   -----------   DEC 20 1983
  WORKING DRAWINGS                 JAN 18 1984   -----------   MAR  9 1984
  PRICE APPROVAL                   JAN 27 1984   -----------   MAR 28 1984
  MATERIAL REQUISITIONS            FEB  8 1984   -----------   APR  3 1984
  CONSTRUCTION START               MAR 14 1984   -----------   APR 18 1984
  CONSTRUCTION COMPLETION          MAY 15 1984   JUN 30 1984   -----------

  CURRENT BUDGET: $   75,000                        PERCENT COMPLETE:   45%
  CURRENT STATUS: Project proceeding on schedule

========================= LAST UPDATE: MAY 30 1984 ==========================


               MOOT COURT ROOM RENOV LAW SCHOOL

   DESIGN W.O. NUMBER: 74809                           ALT. ID:
   CONSTRUCTION W.O. NUMBER:                           ADM. UNIT: LAW
   PRIORITY: B                                         DEPARTMENT:
   REQUESTOR: Wenger                                   BLDG/RM: LAW SCHOOL
   REQUEST DATE: JAN 20 1984                           CONSULTANT:
   ORIGINAL BUDGET: $   60,000                          Cleveland & Sheeran
=============================================================================

  PROJECT MANAGER:                                 CONSTRUCTION SUPERVISOR:
     DORRIER      924-6996                                        -

                                     PLANNED       CURRENT       ACTUAL
  PROJECT PROGRAM                  MAR 23 1984   -----------   APR  6 1984
  PROGRAM APPROVAL                 MAR 30 1984   -----------   MAY 21 1984
  SCHEMATIC DRAWINGS               APR 13 1984   -----------   MAY 10 1984
  PRELIMINARY DRAWINGS                 N/A           N/A           N/A
  WORKING DRAWINGS                 MAY 18 1984   JUN  1 1984   -----------
  PRICE APPROVAL                   JUN  1 1984   JUN 15 1984   -----------
  MATERIAL REQUISITIONS            JUN  7 1984   JUN 22 1984   -----------
  CONSTRUCTION START               JUL  1 1984   JUL  2 1984   -----------
  CONSTRUCTION COMPLETION          AUG 15 1984   AUG 31 1984   -----------

  CURRENT BUDGET: $  103,000                        PERCENT COMPLETE:    0%
  CURRENT STATUS: Development of working drawings in progress.

========================= LAST UPDATE: MAY 24 1984 ==========================
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Figure 1

June 5, 1984

All Elements
Distribution List

```
A:*PRE          FLAG: A    PRESIDENT'S OFFICE
Hereford Jr., Mr. Frank L.
President of the University of Virginia
President's Office
Pavilion VIII East Lawn


A:PRE  AUD      FLAG:      AUDITS
Kovatch, Mr. Richard A.
Director of Audits
Audit Department
Carruthers Hall


A:PRE  BOV      FLAG: F    BOARD OF VISITORS
Bice Jr., Mr. Raymond C.
Secretary, Board of Visitors
Pavilion VIII
East Lawn


A:PRE  LGL      FLAG:      LEGAL ADVISOR
Grattan IV, Mr. George G.
Legal Advisor
Pavilion VIII
East Lawn


A:PRE  MINA     FLAG:      MINORITY AFFAIRS
Jones, Mr. Donald W.
Assistant to the President
President's Office
Pavilion VIII East Lawn


B:*VPA          FLAG: A+F  VICE PRESIDENT FOR ADMINISTRATION
Haas, Mr. Raymond H.
Vice President for Administration
Levering Hall


B:AVPA          FLAG: AF   ASSOCIATE VICE PRES FOR ADMINISTRATION
King, Mr. John H.
Assistant Vice President for Administra.
Levering Hall


B:AVPC          FLAG: *    ADMINISTRATIVE COMPUTING SERVICES
McCormick, Mr. James A.
Acting Asst Vice President for
Administrative Computing
Carruthers Hall
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Figure 2

Quality Circles in Physical Plants

By Shelley K. Merrill
Iowa State University

Quality Circles are one of the fastest growing management tools in the country today. While their roots are in the industrial sector, they are rapidly gaining momentum in the government and service sectors as well. QCs hold great potential for Physical Plants in their quest to meet the challenges of professionalism in management of human resources.

Iowa State University Physical Plant implemented a pilot quality circle program over a year ago. The purpose of this paper is to discuss what QCs are, explain why they are so effective, relate our experiences with QCs and provide suggestions for implementing circles in other Physical Plants.

What are QCs?

A QC is a group of 7-10 employees from the same or related work areas who meet on a regular basis to identify, analyze and solve problems in their area. These problems may include product or service quality, efficiency, cost reductions and safety. QCs do not discuss personnel policies, personalities, wages, hours, terms and conditions of employment or grievances.

Members participate voluntarily and meet regularly, usually for one hour a week on company time. These are structured groups and use structured techniques. One person, often a supervisor, serves as the leader of the circle. He or she will prepare the agenda, lead the meeting and ensure that QC rules are followed. A facilitator is also appointed. This person coordinates circle activities in the organization, helps resolve group problems both in the circle and between the circle and management, and assists with training. A steering committee sets goals and objectives for QC activities, establishes operational guidelines and controls the rate of expansion of circles in the organization.

Each circle receives training in QC techniques - problem solving, problem prevention, brain-storming, data gathering, decision analysis, cause and effect problem analysis and presentation techniques. Each circle also establishes a code of conduct for how their meetings will be run. Then, following these techniques and rules, they identify, select, analyze and solve problems related to their work, often using information and advice they've requested from various resource people outside the circle. When the problem is solved, the QC will then make a formal presentation to management, describing their project and recommendations. Management will then decide whether or not to act on the idea. Regardless of acceptance, response to the group is to be timely and reasonable. Management is not abdicating responsibility or control - they are receiving valuable input from the people closest to the problems.

The objectives of QCs are often stated as these 7 goals: (1) improve quality, (2) create "problem solving" and "problem prevention" attitudes, (3) promote active job involvement, (4) develop more effective teamwork, (5) promote personal development, (6) reduce errors, (7) promote cost reductions.

Why are Quality Circles growing?

QCs were originally an American idea, proposed in the late 1950's, however it was the Japanese who first implemented the technique on a large scale. After observing the obvious success of Japanese industry, U.S. firms began to show interest. Ten years ago, Lockheed started the first major QC program in the U.S. The concept started slowly but quickly grew, such that there are now over 7,000 organizations, and more than a million employees involved in QCs. QCs can be effective in any type of organization and with any type of employee group - clerical, engineering, crafts, or custodial.

Why all the interest in QCs? The first and most obvious reason is that they promote cost reductions, are cost effective in doing so, improve quality of work or service, and improve efficiency.

But the biggest benefits of QCs are the "intangibles" - increased motivation, morale, job involvement, teamwork, and employee-management communication.

We are entering a new era in the workplace. Gone are the days of Theory X, authoritarian management when orders were given and employees told they got paid to work, not to think. We now know that decent wages, benefits and working conditions alone do not motivate performance. Because of union contracts and structured pay plans, we can't give true merit increases or bonuses to reward or stimulate productivity. What does stimulate performance is worker involvement, participation, responsibility, recognition and esteem. Workers today are better educated and are demanding more say in their jobs and fuller use of their abilities and ideas. Management is coming to the realization that one of their greatest untapped resources is the expertise and knowledge of their workers.

It is obvious the workplace is gradually moving toward a more participative and democratic environment. The transition will not be easy and attitudes will not change overnight. QCs are not the only way to achieve a Theory Y type of organization, but it is one technique to use in helping your plant move closer toward those ideals.

QCs at ISU Physical Plant

In spite of their growth, QCs are not yet common in university environments or in Physical Plants. ISU started a pilot QC program in January, 1983. An ad hoc group of individuals having an interest in the concept formed a steering committee. We requested and received funding to obtain a consultant, formally train three of our members, and obtain manuals and training materials. Steering committee members served as facilitators. Three circles were started - one of professional employees in the Purchasing Department, one of clerical employees in Engineering Extension, and one of blue collar employees in Physical Plant. Our plant's first circle was in the campus service area. Leaders and management staff attended leader training which focused on QC techniques and group dynamics. A presentation was then made to Campus Service employees asking for volunteers. Out of a shop of 50, we were pleasantly surprised to have over 20 volunteers. Ten names were drawn out of a hat to form our first circle. The first ten meetings were spent on training. The group established their code of conduct, selected a group name, brain-stormed a list of possible problems and selected one to work on. As this group is responsible for snow removal, one of their big problems each year was struggling with tire chains. They analyzed whether or not the shop snow removal equipment should have fluid-filled tires rather than use chains, and ended up making that recommendation based on cost reduction, safety, and turf damage considerations. Their management presentation was very impressive and rewarding. They had researched all the pros and cons, performed surveys of other institutions, analyzed costs, and drew up charts and graphs showing all the facts. They had even created a video tape to demonstrate the safety aspects. Their idea was accepted and implemented this past winter, and resulted in a $3,000 annual savings. The group has since tackled two other problems dealing with sand and gravel storage and equipment storage.

We felt it was important to document the benefits of the program in order to justify continuing and expanding it. In addition to the cost savings, we attempted to document changes in employees' attitudes by administering surveys and structured interviews at various intervals - before and after training, and after nine months' experience. Questions were asked concerning their problem solving/prevention attitude, their feeling of active job involvement, their experience of effective teamwork and their experience of personal development through their work. Significant positive improvement was shown in all areas.

Based on this good experience, we decided to expand and add two more circles last January. Again, it was on a volunteer basis. We started one in our custodial service, and one for our area mechanics. The groups are finishing their training at this point, and we're anxiously awaiting their first management presentation.

We're very high on QCs and feel they have real potential in helping Physical Plants modernize their management styles and remain cost effective. We all are anxious to computerize our information systems, automate our building systems, and utilize the latest engineering techniques. Being at centers of learning, we should also strive to be on the leading edge of human resource management philosophies and techniques as well. QCs are a technique we should all consider.

Implementing a successful QC program

We have identified some important steps in implementing a successful program.

1. Gain commitment from the top. The program is doomed to failure if top management only gives lip service to the idea and the philosophy behind the idea. Establish a receptive atmosphere by informing your various management levels of the technique, the concept behind it and its importance. Also, strive to gain the support of your union so they fully understand the benefits employees will receive by participating and understand that the program is not intended to undermine the union.

2. Establish a steering committee. This group should consist of interested individuals from management, a personnel or training function, and an employee representative. They will get the program started, determine how to proceed, establish objectives, set a timetable, and do initial training and presentation of the program.

You may choose to hire the assistance of a consultant. You may also choose to join the International Association of Quality Circles, based in Cincinnati, and utilize the help of that organization. It has several local chapters scattered throughout the country. Being at a university, you also have unlimited free information and help at your fingertips. There are books and articles in the library, professors with interest in this area, and countless students eager to gain practical experience. We have used students to administer surveys, serve as facilitators, and assist with training.

3. Select the right people and the right area. Many areas may volunteer to be your first circle. You should select the first group based on your perception of their likelihood of succeeding. At first, the circle leader should be a supervisor, as they will have the necessary background and skills. Leadership can later be rotated if it seems appropriate. The facilitator is a key individual and should be a skilled communicator, have traits of a good teacher, be self-motivated, and believe in participative management. Someone from the personnel office, a student volunteer, or someone on your staff may fit this description. Facilitating will take approximately two hours a week of their time.

Keep the membership voluntary. Pressure or force will not work to motivate people.

4. Training is crucial. Train leaders in how circles should be run. Train facilitators on group dynamics, counseling techniques and intervention skills. Train members on QC techniques and meeting rules - and insist on their adherence. This will keep meetings from degenerating into gripe sessions, keep projects moving, and ensure that everyone has an opportunity to participate.

Train your managers on how to deal with QCs. This is new and different for them. Go through the training on QC rules and techniques, so they understand what the group is doing. Assure them their managerial ability will not be questioned because the circle is identifying problems in their area. Every area has more problems than can be solved. Be sure they are creating an atmosphere of acceptance and support for QCs. Train them in how to react to a management presentation - an inappropriate response could undo all the good of the program.

5. Start small and let it grow slowly and steadily. When starting a new program, care should be taken so that it is not a burden to the organization. It takes time and effort to get a QC program operating. Don't be impatient. Personal development is a process, not an event. Don't expect the circle to quickly generate solutions to many problems. It takes them time, also, to learn teamwork, group problem solving and QC skills and techniques.

6. Publicize the program and provide recognition to the people involved. Use your plant or university newsletters to publicize activities and accomplishments.

We held a formal presentation ceremony in the President's conference room after training was complete. The Vice President and Dean of the respective areas presented certificates to the QC members. We are now ordering QC pins for the members who have been in circles for a full year and will also have an awards ceremony for this accomplishment.

It doesn't take a big budget to start QCs. It may be easier and quicker to obtain a consultant to help get started, and it may be easier to purchase training materials rather than develop your own, but neither is necessary. Be creative in your use of university resources. There is a lot of free help and advice on campus.

QCs are worth the effort! They are a proven technique to use in helping management staff adapt to the workplace trends forming our future. QCs are a proven technique to use in stimulating employee productivity, job satisfaction and involvement. The sooner we recognize that every worker is a source of ideas, not just a pair of hands, the sooner we will fully utilize our human resources. I encourage each of you to consider QCs for your Physical Plant.

Variable Volume Fume Hood System

By Dennis Buchenholz
IMEC Corporation

Introduction

A new fume hood control system was developed to save energy while allowing increased safety. Since fume hoods can waste upwards of $2,000 of energy per year (ref. Appendix), the potential energy savings can be quite large. The presentation of this new system is divided into three parts. The first section reviews the energy and safety problems inherent in present day fume hoods. The second section describes the previous approaches that have been used to solve these problems and explains why they are not complete solutions. The third section then gives the details of the new approach and shows how the problems have been addressed from a systems viewpoint.

Problems With Fume Hoods

A quick review of the needs for and requirements of fume hoods in today's laboratories will help to put things in their proper perspective. Many industrial and laboratory operations release airborne contaminants that are harmful to employees working in that environment. Ventilation is a popular method for reducing employee exposure to these contaminants. There are two types of ventilation for contaminant control: dilution ventilation which reduces contaminant concentration by diluting it with fresh air; and local exhaust ventilation systems which capture or contain contaminants at their source before they are dispersed in the workroom. This paper concentrates exclusively on a particular kind of local exhaust system -- fume hoods.

Fume hoods have been in existence for approximately 50 years. Their primary purpose has always been to prevent or minimize the escape of contaminants from the hood back into the laboratory. The early designs were similar to today's conventional fume hoods. They consisted of an enclosure with a sash that can be raised or lowered. A constant volume of air is drawn through the opening and exhausted outside the workplace. The major drawback of these conventional hoods is the excessive face velocity that occurs when the sash is lowered.

Too high a face velocity is as much of a problem as not enough. High face velocities produce air turbulence and eddy currents. These swirling air movements bring contaminants from inside the hood out into the workplace (ref. Figure 1). Additionally, excessive face velocities can blow out Bunsen burners or tip over laboratory apparatus in the hood.

Bypass hoods were developed to help solve this problem and have replaced the conventional hood as the standard in today's laboratories. The bypass is located above the sash opening. As the sash is lowered, the bypass is uncovered in proportion to the work area opening being closed (ref. Figure 2). By keeping the total opening to the hood constant, a constant volume of exhausted air will provide a constant face velocity. This constant face velocity is one of the key factors in the safe operation of a fume hood. It should be noted that not all bypass hoods are designed to maintain a constant face velocity. Some bypass hoods actually vary the face velocity by a factor of 3 or 4 times.

In the early 1970's, rising energy prices forced people to take notice of the significant energy waste associated with fume hood operation. Based on continuous operation in the greater Boston area, a fume hood wastes over $2,000 of energy per year. (Appendix A describes in detail how these costs are calculated.) While several attempts have been made with varying success to reduce the energy consumption in new hoods, there still exists a large installed base of energy-wasting fume hoods. And as energy costs continue to rise, the operation of these fume hoods becomes more expensive from year to year.

While the energy consciousness of many fume hood users is growing, it is unfortunate that their safety awareness is not as great. Many people have been lulled into a state of mind that fume hoods are safe. It's easy to see why. The Williams-Steiger Occupational Safety and Health Act of 1970 heightened interest in industrial ventilation. Practically overnight, recommendations and guidelines were published by many organizations. Federal and State regulations were enacted to help protect employees from exposure to contaminants. The fume hood manufacturers then translated these requirements into better designs and improved air flow techniques for fume hoods. However, there are no safey features designed into today's fume hoods which continuously monitor its performance over time.

How does the user know a fan belt isn't broken or slipping? How does the user know the face velocity isn't below its minimum acceptable rating? How does the user know the motor isn't working? A few months ago I visited a local company and brought along an air flow meter. After taking measurements of several hoods, I noted that the face velocity was below the acceptable minimum. After informing the lab manager of my findings, he said, "That's funny. We use cyanides at that hood." (Later on, someone joked "not for long.") Unfortunately, the situation where face velocities are unknowingly below safe levels is more common than everyone would like to believe. While some organizations have a safety program which periodically measures fume hood performance, there is no continuous monitoring of the fume hood in between these checks.

This brings us to the major problems with present day fume hoods. They continue to waste significant amounts of energy. Additionally, there is no continuous monitoring of operation to insure the user's safety. The next section will describe the various approaches that have been tried to solve these problems.

Previous Approaches

Before discussing the historical approaches to the problems of fume hoods, it should be noted that almost all of these solutions are aimed at solving the energy problem only. Not only is little attention paid to the safety problems, but safety is even compromised for energy savings. As a matter of fact, it wasn't until recently that separate solutions have been offered to correct the safety deficiencies.

During the energy crisis of the early 1970's, auxiliary air hoods were the first attempt to solve the energy problem. Auxiliary air hoods attempt to reduce the conditioned air that might otherwise have been exhausted by providing a separate supply of air that has not been tempered. This untempered air is usually supplied in front of the face of the fume hood (ref. Figure 3).

The air flows in auxiliary air hoods present some problems if they are not properly adjusted. Chemists or scientists working at these hoods can be bothered and inconvenienced by the cold or warm draft of air pouring down over their heads as they work. This problem is such a nuisance that many operators have attempted to block these supply air outlets resulting in seriously unbalanced systems and little or no energy savings. More importantly, if the temperature difference between the room air and the auxiliary air is too large, the resulting air movements become unsafe. With large temperature differences, much of the auxiliary air will not enter the hood but will flow right past the hood opening sweeping with it some of the contaminated air from inside the hood. This air movement is also adversely affected by introducing the auxiliary air at the wrong velocity.

In order to eliminate the safety problems associated with auxiliary air hoods, the auxiliary air must be tempered before it is introduced into the laboratory. This results in much less energy savings than is usually advertised. Another often overlooked disadvantage of auxiliary air hoods is the extensive duct modification and expense that is required to install them. Despite the penalty for safety, auxiliary air hoods do save some energy. They are also a good solution for laboratories with make up air problems.

The next approach that was tried were many different kinds of two-speed systems. These two speed systems can be based on a dual fan/motor combination, a magnetic particle clutch assembly, or a variable speed drive. All three variations are used with one limit switch which is placed on the fume hood to sense sash position.

All of these two speed systems produce widely varying face velocities which is an unsafe condition. As the sash is lowered and before it trips the limit switch for the lower speed, the speed of the fan remains constant. By drawing the same volume of air through a smaller opening, the face velocity increases. As the limit switch is tripped, the face velocity then drops dramatically since the fan is now running at the slower speed. An often overlooked fact with these two speed systems is that they do not save any energy unless the sash is moved to a position which trips the limit switch. Usually this limit switch is placed 6" above the bottom of the opening. Thus while the operator is using the hood, there is no savings of energy. Additionally, since this turndown is fixed, the system has little flexibility to be changed for different operating conditions. Despite these problems, the two speed systems do save energy with a reasonable payback. They also offer a cost effective and safer alternative than completely turning off the blower motor.

Systems that use a variable speed drive are sometimes set up in an open loop mode with just a potentiometer nearby the hood. These open loop systems are the first step in making the fume hood into a VAV system. While the open loop systems can be set to any turndown, there is no way of insuring that the potentiometer is adjusted appropriately for any particular sash position. This results in face velocities which may not be set at safe levels.

The two speed and open loop systems that use a standard variable speed drive have a unique problem which is very dangerous in the fume hood application. These drives shut down if a power transient or outage occurs on the power line and do not automatically restart when the power comes back. This could shut down a fume hood with no warning to the operator who is performing his/her work. A Boston area university installed standard variable speed drives on over 100 fume hoods in one building and learned of this line outage problem the hard way. The problem was so severe that they had to assign a physical plant employee to the penthouse to make periodic checks on the status of these variable speed drives every 20 minutes, 24 hours per day, 365 days per year. If the employee had to leave the area for even a 10 minute break, he had to be relieved by another employee to cover in his absence.

The horizontal sash hood is another energy-saving device that has been offered. This can be in the form of original equipment or as a modification to an existing vertical sash hood. There are some problems with horizontal sashes, the major one being that the users do not like them because the sash obstructs their work and makes them less productive. If horizontal sashes are retrofitted to an existing veritical sash hood, care must be taken to modify the bypass properly. If not, the fume hood will operate just like a conventional hood with widely varying face velocities. Furthermore, a leading fume hood manufacturer believes that the use of horizontal sashes causes air turbulence and eddy currents resulting in unsafe ventilation. From an energy point of view, horizontal sashes save only a fraction of the energy savings possible. However, their low cost makes them a viable option for some laboratories.

Recently the fume hood manufacturers have begun to offer add-on safety devices which continuously monitor the hood's face velocity. All of these devices work off of a static pressure gauge which measures pressure in the duct. These devices are based on a constant flow (constant volume) system. Since the static pressure in the duct is proportional to the flow squared, a change in static pressure reflects a change in flow and therefore a change in face velocity. While these safety devices do solve one particular problem with fume hoods, they are difficult to integrate into any variable air volume system or two speed system designed to save energy. Since the flow is not constant in these systems, the static pressure sensors cannot distinguish between a lower setting or a real problem with flow. Thus static pressure sensors cannot be used in these types of systems to monitor safety.

A New Systems Approach

A new variable air volume (VAV) fume hood system has been developed which simultaneously saves energy and increases safety. The importance of this development lies in the fact that it ties in to the major move to VAV in the general HVAC area. Physical plant and building management personnel are beginning to look at VAV as a way to lower operating costs. A laboratory cannot be converted into an energy saving VAV installation unless the exhaust flow, which is usually dominated by fume hoods, can be reduced. The use of VAV fume hood systems can also lower the initial capital costs of installing air heating and cooling equipment. Since the total air flow from fume hoods in one area will average to a rating below the peak rating, the air tempering equipment can be downsized accordingly.

Before the system is described in detail, it is worthwhile to review how this system came about. What triggered the design of this VAV fume hood system was the availability of a unique and patented variable speed drive. The unique feature of this drive is its ability to automatically restart after a power line transient or outage has occurred. Since variable speed drives are used to save energy, a market was sought which required this automatic restart feature in an energy saving application. This is how the fume hood application was selected. Some local test sites were selected and the product was updated with inputs from users.

The system consists of three components: a variable speed drive to control the blower motor, a monitor mounted on the fume hood to provide safety information, and a sash sensor on the outside of the fume hood to measure sash position (ref. Figure 4). All three units are interconnected with electric wiring. There are no ductwork modifications and there are no sensors which are placed in the contaminated air stream.

The system is based on the concept of variable air volume with constant face velocity (ref. Figure 5). Operation is automatic; as the sash is lowered, blower speed is proportionately lowered thereby reducing air volume. This saves conditioned room air and also keeps face velocity nominally constant. Most of the energy savings comes from wasting less heated or cooled air. Year round conditioning of air can cost close to $2,000 per year in some installations (ref. Appendix). There are also savings in electricity from operating the motor at a lower speed. Since the power consumed by a motor is proportional to the cube of its speed, operating a motor at half speed, for instance, uses one eighth the energy. The energy saving achieved by this VAV system is adjustable up to a turndown of 8:1. Typical usage is closer to a 4:1 turndown resulting in a 60-70 percent savings in energy.

The system has some built-in incentives which insure that typical energy savings are achieved. Since the blower, duct, and hood noise decreases when the air volume is reduced, the operator has an incentive to lower the sash when the hood is not in use. A "relative energy use" meter on the monitor indicates motor speed and gives the user feedback on the degree to which energy is being wasted. A "night energy waste" reminder signals the user when the room lights are turned off and the sash is not lowered. An after-hours security or maintenance person could easily learn to lower the sash when the night energy waste signal is on.

Unlike all the other fume hood energy saving devices, the energy saving features of this VAV system are integrated with many safety features. Furthermore, the features are packaged into a system with standard interfaces for easy integration with existing building energy management systems. The primary safety feature is a nominally constant face velocity. Since the air flow is proportional to the hood opening, the bypass must be blocked to produce a constant face velocity.

Another important safety feature is the constant monitoring for lower-than-normal face velocity. This can occur because of a jammed blower, a broken or slipping belt, a motor fault, or a severe brownout. This VAV system monitors for these conditions electronically without any static pressure or air flow sensors. Since the power consumed by a motor is proportional to the cube of its speed, a unique aspect of the system measures the motor power and compares it to the expected power at the commanded speed. The user is alerted if too large a difference exists between the two. A constant green light remains on when conditions are normal.

An emergency exhuast capability exists for those conditions requiring higher than normal flow. This is an extremely important capability in any VAV system which can reduce air flow. Since high flow may be quickly required while the hood is operating in a low flow mode, failure to have some kind of override could make the hood unsafe in certain situations. The emergency exhaust capability for this VAV system consists of a pushbutton on the monitor. When initiated, this will rapidly evacuate the hood in case of a fire, spill, sudden evolution of gas or potential hazard during an exothermic reaction. This capability can be exercised manually by the pushbutton on the monitor or by a remote switch located elsewhere in the laboratory. The emergency exhaust capability can also be automatically initiated by external temperature or gas sensors. (For those situations requiring lower-than-normal face velocity during a fire, the VAV system can be wired accordingly.)

A convenient safety feature of this VAV system is the ability to set the face velocity at the fume hood with just a screwdriver and an air flow meter. By taking off the cover of the monitor, a few controls can be quickly adjusted for the proper face velocity. This allows personnel from the safety office to periodically check and maintain proper working fume hoods without having to send a requisition to maintenance to adjust a pulley or belt in the penthouse.

As mentioned earlier, this VAV system has many interfaces to tie into existing building energy management systems. With the introduction of variable air volume on the exhaust side of ventilation systems, it becomes important to balance the entire system by controlling the supply side as well. This VAV system has two interfaces for control of the make up air. Additionally, there is a noticeable savings in electricity from operating the supply fan at slower speeds. Relay contacts are also available to indicate a low face velocity condition exists or that the emergency exhaust capability is being used. All these interfaces can be used by a security or energy management system.

This VAV system can also be wired to monitor energy savings at a central location. Either one of the two interfaces for controlling the make up air can be used to monitor how much energy is being saved at each individual fume hood. This allows the people responsible for the energy budget to pinpoint energy wasters.

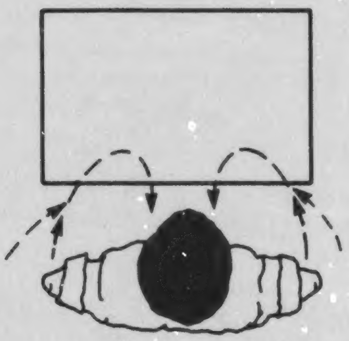
It should be noted that with the advent of VAV or two speed systems a new set of problems become evident. For instance, there are some state laws which govern the discharge velocity of certain toxic chemicals. As the flow rate is reduced, so is the discharge velocity. Thus, it becomes important to be able to adjust the turndown of a VAV or two speed system to insure that these safety laws are being followed. Since the VAV system introduced in this paper has simple adjustments for turndown right at the monitor, it can be quickly adjusted to meet these laws.

An existing problem that can get worse with any reduced flow system is the backpressure problem. Reduced flow systems include any VAV, two speed or horizontal sash system. This occurs because of insufficient make up air resulting in negative pressures (or backpressure) which tend to suck air into the room. While this air can enter the laboratory through doors, windows, and hallways, it also lowers the flow in a fume hood by effectively producing a resistance to exhausting air. When a VAV system is in a low flow mode this becomes especially noticeable and produces a drop in face velocity. The introduction of a VAV system can help relieve this problem, but it must be flexible enough to correct for lingering backpressure. The VAV system introduced in this paper has a two point face velocity adjustment (at maximum and minimum flow) to correct for potential backpressure problems.

The VAV system introduced here can help solve energy and safety problems that exist in today's laboratories. It is especially useful in those laboratories that have heating and/or cooling capacity problems. For that matter, any application that involves a capital cost savings will significantly reduce the payback period. Most importantly, however, when the various functional areas review this system, the safety people and the energy people will finally be on the same side. Now an opportunity exists to make the workplace a safer and more energy efficient environment.

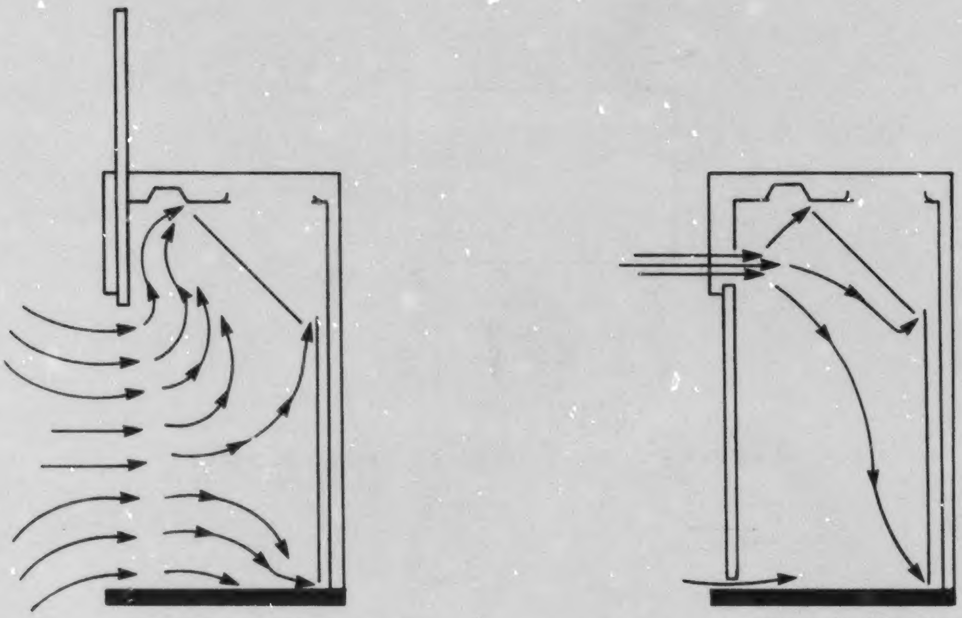
Summary

Two major problems exist with today's fume hoods: energy waste and lack of monitoring devices for safety purposes. The historical approaches to solving these problems have focused on only one of these problems, not both simultaneously. Despite this fact, some of the existing devices are useful in certain situations. The variable air volume (VAV) fume hood system introduced in this paper is the most complete solution to these two problems. It also ties in to the major move to VAV in the general HVAC area by reducing the flow of exhausted air and allowing energy saving VAV equipment to be installed.



AIR MOVEMENT FROM EXCESSIVE FACE VELOCITY

FIGURE 1

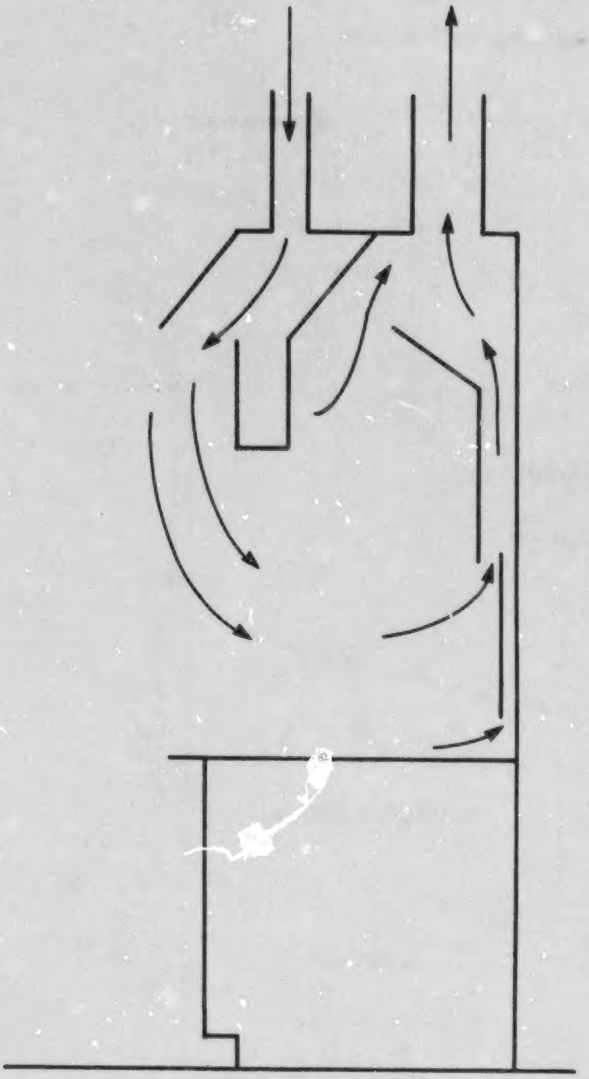


SASH OPEN

SASH CLOSED

BYPASS HOODS

FIGURE 2



AUXILIARY AIR HOOD

FIGURE 3

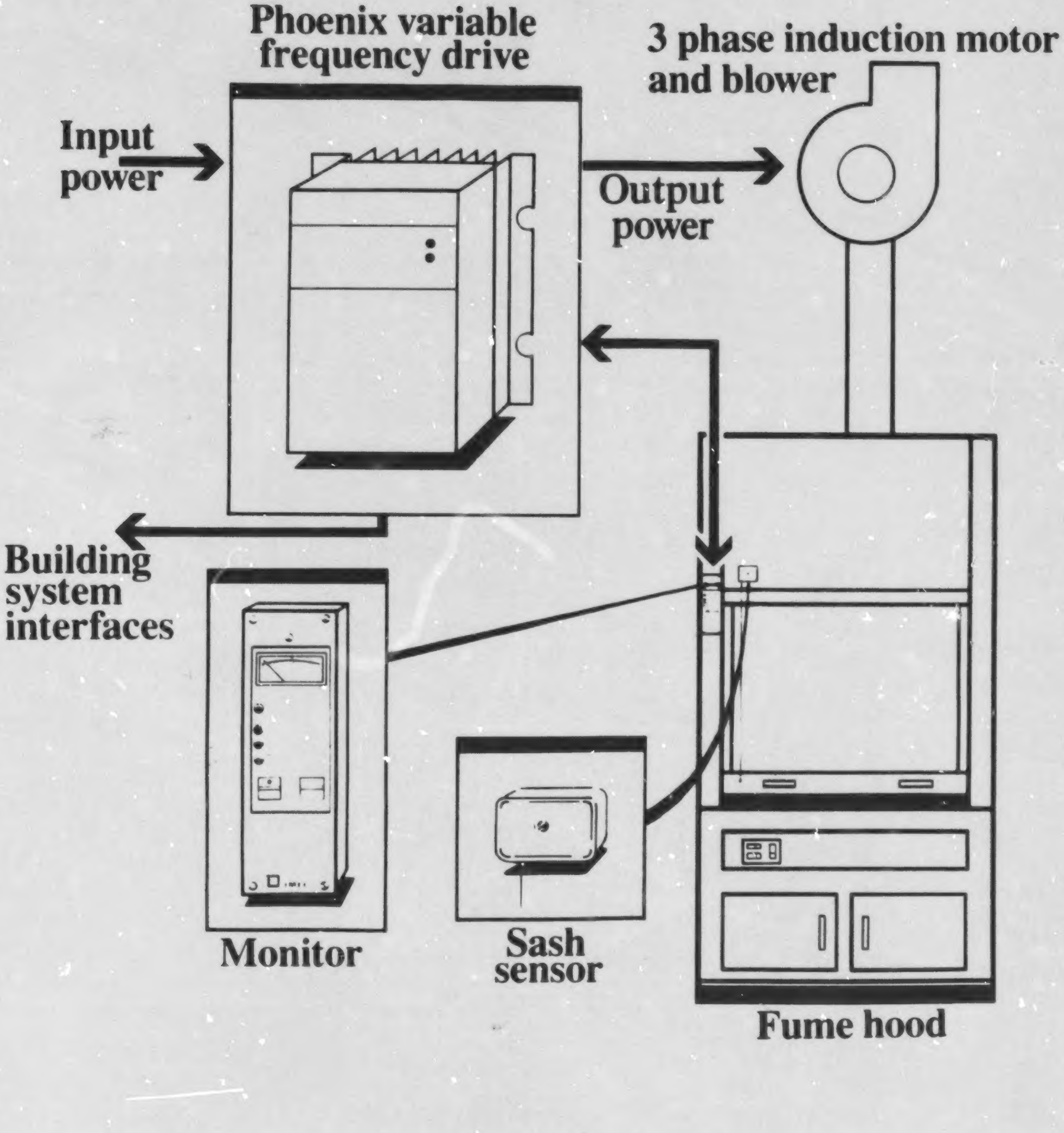
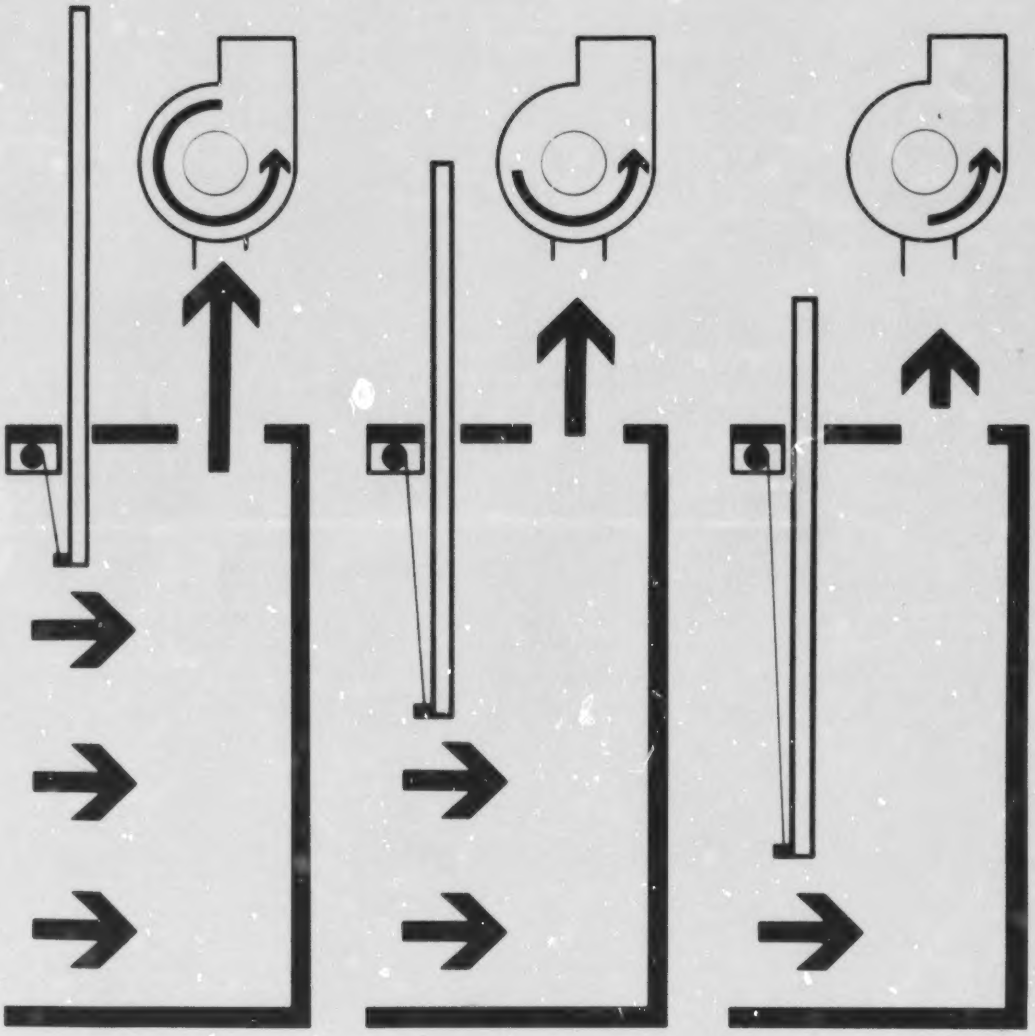

Phoenix variable frequency drive
3 phase induction motor and blower
Input power
Output power
Building system interfaces
Monitor
Sash sensor
Fume hood

FIGURE 4

Variable volume with constant face velocity



Variable blower speed

Variable volume

Sash sensor →

Constant face velocity

FIGURE 5

Appendix

YEARLY COST OF A TYPICAL 6 FOOT FUME HOOD IN THE GREATER BOSTON AREA

Energy is a significant part of the annual operating cost of a laboratory fume hood. The annual energy cost associated with operating a typical 6 foot fume hood in the greater Boston area is estimated as follows:

HEATING AIR	$1735
ELECTRICITY FOR EXHAUST FAN	305
ELECTRICITY FOR MAKE-UP AIR FAN	305
COOLING AIR	180
	$2525

The balance of this appendix will describe in more detail how these numbers are calculated.

HEATING AIR

A standard 6 foot wide fume hood has a face area of 12 square feet. With a conventional face velocity of 100 feet/min, the volume of air exhausted is 1200 CFM (cubic feet/min). Since users run their fume hood at face velocities anywhere from 60 ft/min to 150 ft/min, the CFM will vary accordingly.

As this tempered air is exhausted out of the building, it must be replaced with outside air. To keep the laboratory at a comfortable temperature, the outside replacement air must be heated. As the following formula and example will show, heating replacement air is a significant expense.

The annual heating costs associated with the operation of a fume hood system can be calculated from the following equation:

$$\text{COST} = \frac{0.154 \times Q \times T \times DD \times CF}{q}$$

where Cost = annual heating cost (dollars)
Q = Volume of air flow (ft^3/min)
T = Operating time (hr/week)
DD = Annual degree days
CF = Cost of fuel (dollars/unit)
q = Available heat per unit of fuel (see Table 1)

TABLE 1

Fuel	Available Heat
Coal	6000 BTU/lb
Oil	100,000 BTU/gallon
Gas	800 BTU/ft^3

Example: What is the annual heating cost associated with operating a fume hood of 1200 CFM for 168 hours/wk (constant volume) using oil in Boston, MA?

Assumptions:
- Cost of oil $1.00/gallon
- Ambient temperature 65 degrees F

SOLUTION

A normal year has 5621 heating degree days assuming a base temperature of 65 degrees F. From Table 1, there is 100,000 BTU of heat available per gallon burned.

$$c = \frac{0.154 \times Q \times T \times DD \times CF}{q}$$

$$= \frac{0.154 \times 1200 \times 167 \times 5621 \times \$1.00}{100{,}000}$$

$$= \$1735/\text{year}$$

ELECTRICITY FOR EXHAUST FAN

Electricity is the usual power source to rotate the exhaust fan. The cost of moving a fan can be calculated from the horsepower (HP) rating of the fan motor. For a single exhaust fume hood, or two or three fume hoods ganged to one exhaust, the horsepower rating of the fan motor is usually 1/2 to 1 HP. Due to friction losses in the motor, more than 1 HP of energy has to be input to receive 1 HP at the output. Typical efficiency ratings for these low horsepower motors are between 65% and 75%. By definition, 1 HP = 745.7 watts, or approximately 0.75 kilowatts (KW). The following formula and example will show the annual operating cost of a fan motor.

$$\text{cost} = \frac{0.75 \times HP \times T \times K}{E}$$

where cost = annual electricity cost (dollars)
HP = horsepower rating
T = operating hours/year
K = cost of electricity in dollars/KW-hour
E = motor efficiency

Example: What is the annual cost of electricity associated with continuous operation of a 1/2 HP fan motor with a 70% efficiency rating assuming an electrical rate of $0.065/KW-hr?

$$C = \frac{0.75 \times HP \times T \times K}{E}$$

$$= \frac{0.75 \times .50 \times 8760 \times 0.065}{.70}$$

$$= \$305/\text{year}$$

ELECTRICITY FOR MAKE-UP AIR FAN

Make-up air fan costs can vary considerably. They might appear to be zero or could actually be as much as the heating costs.

At the low end, costs would appear to be zero at installations that have no make-up air system. Make-up air is supplied through infiltration of windows, cracks, doors, etc. However, such buildings often run at significant negative pressures requiring higher exhaust fan horsepower. For example, a 1 HP exhaust fan motor might be taking the place of a 1/2 HP exhaust fan motor and the equivalent of 1/2 HP in a make-up air system. Thus a no make-up air installation would consume an equivalent amount of electricity resulting in no savings.

A normal situation would involve make-up air systems run at moderate pressure. In this case the make-up air fan motor would consume about the same amount of electricity on a per hood basis as the hood exhaust fan.

At the other extreme some buildings have high pressure make-up air systems and considerably higher make-up fan costs. Make-up air systems are rarely designed as high pressure systems but they become that way by default. A common example is a laboratory or building that was designed for 10 fume hoods but now has 15 or 20 hoods. The ventilation system and in particular the make-up air ductwork were sized for the original 10 fume hoods. Without enlarging the ductwork (which is a costly job), the only way to supply added make-up air capacity is with a higher horsepower fan motor. This results in a high pressure system.

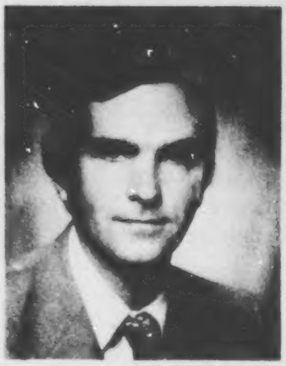
A quick review of the Fan Laws provides an interesting insight here. Two of the Fan Laws are as follows (both laws assume the ducts are not changed):

1) Volume varies as the fan speed
2) Power varies as the cube of fan speed

In the example above, doubling the number of fume hoods will double the volume of air required which in turn requires a doubling of the fan speed. However, the power (HP) required by the fan motor increases by a factor of 8 (2x2x2). In this case the electricity for the make-up air fan costs as much as heating the air.

COOLING AIR

It is difficult to estimate the cost of cooling air since air conditioning systems have many different designs and are operated in different ways by the end user. How the systems handle humidity is an important varying factor. A conservative estimate for cooling air costs per fume hood is $180/year. This is based on a cost of $0.20/fan-hour to cool the outside air down to 75 degrees F in the greater Boston area.



Computerized Maintenance Management for the Personal Computer

By P. Marques Davidson C.M.C.
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New York, New York 10036

The advent of the Personal Computer with a hard disc drive has made the use of the Personal Computer (PC) possible for maintenance management. It is now possible, using a PC, to store information about facilities and equipment to be maintained, issue preventive maintenance work orders, issue repair and renovation work orders, track labor and material costs, provide scheduling information, provide work histories, and produce meaningful management reports.

Using a computerized maintenance management package requires an effort of data entry and daily inputs to get the maximum benefit from the system. After the initial effort, the daily inputs will require less time and provide more information than can be obtained from utilization of a manual system.

How do you begin to implement a maintenance management program?

With or without a computer, the most important step in beginning a maintenance management program is determining what is to be maintained and determining the appropriate maintenance procedures and methodology.

Maintenance planners have to be assigned and trained. The inspection tasks, inspection frequencies and standard times for each piece of equipment have to be determined, and inspectors, preferably selected from the craft areas, have to be trained for new assignments and responsibilities.

Stockrooms have to be designed, parts listings made, and stock quantities established. Maintenance contracts for repairs have to be let, or in-house repairmen upgraded. The most efficient method is to employ all existing resources without hiring of additional personnel. Tools and equipment needs for repair have to be determined.

For the program to be complete, much work on the support functions has to be accomplished. A complete inventory of all equipment, nameplate data, identification of all components and examination of all maintenance manual information is accomplished, and the information put on file.

Using the computer, to establish a PM program, filed information about each component is instantly analyzed (see Diagram I). The analysis is subjected to a "Decision Tree," stored in the computer. From the "Decision Tree," the appropriate inspections, assigned amounts of time and inspection intervals for that particular piece of equipment are chosen, and made a part of the permanent record for that piece of equipment (see Exhibit A). Entry of spare parts information for the piece of equipment automatically sets up a record of spare parts utilized by the piece of equipment (see Exhibit B).

Once all the equipment inventory information is in the computer, a special program is activated which takes all the maintenance inspection information and balances the workload of inspections week by week for an entire year. The PM work orders for each given week are printed by the program. The computer keeps track of the status of each request for maintenance work (i.e., in planning, in progress, etc.), and notifies planners of the status, to stimulate any needed expediting (see Exhibit C).

The computer expects the completed inspections to be completed and information to be entered into it on time. Any that are not, immediately show up on a delinquent work list. Work orders for other maintenance work, if not completed on time, also show up on the delinquent work list.

Once completed, all hours and dollars are posted to each equipment's history. They are also automatically accumulated for efficiency and cost reports, created for any period at any time (see Diagram II and Exhibits D, E and F).

Thus, the supervisors at various management levels can identify where the labor hours and dollars are going. Comparisons of effort versus budget, in hours and dollars, are made available. Accountability "tracking," right down to individual work orders, is easily accomplished.

Tracking Work Effort

Assisted by the computer, it now is possible to get a "handle on" the constantly-changing pattern of maintenance work. By insisting on written instructions and records for all work, the status of any individual job, backlog of work in any area, and progress on any job can be instantly analyzed. Expediting can be applied immediately to those jobs of high priority or immediate need.

Delinquent jobs can be identified to planners at any time, so that additional planning or expediting can take place. With copies of the report going to upper management, there is assurance that any inertia in action will be quickly overcome.

Wasted or unused hours of time by department, building and equipment "pop" out for the immediate attention of management. Such analysis can be done at any time and for any designated time period.

Costs for maintaining each building can be identified readily. Finally, maintenance costs for an entire complex of buildings can be determined and integrated into an accounting system by account code.

Integrated into the system is control of parts, materials and tools, probably half the cost of maintenance. For each job, the planner defines material and tool needs. For actual work, parts and material usage can be closely tracked and the effect on inventory watched. Reordering of economically justified quantities is automatically signalled by the computer when reorder points are reached. There is a printed report of information on all parts currently needing to be ordered.

Constant attention is focused on changes in inventory. The computer even sets aside inventory for special requirements of project or scheduled work. The computer gives instant status on usage, availability, how much is on order and from what vendor, at what price (see Exhibit G).

With standardization of inventory numbering and description, a standardization of parts inventories can be accomplished. Through standardization, centralized inventories can be set up and distribution made from such inventories. All this gives the opportunity for bulk buying, with corresponding savings from issuance of blanket purchase orders.

Stitch In Time

By using the computer to provide instructions, periodic inspection and servicing can take place automatically (see Exhibit H). Potential failure spots can be identified. Identifying potential problems before they occur enables management to fix equipment with minimum downtime, as opposed to lengthened loss of usage when equipment breaks down.

Result: more time on the "line," and greater output with lower unit costs. Catching problems before they occur has the added advantage of reducing repair costs. Avoiding the breakdowns that can snap shafts, tear up bearings and ruin equipment goes a long way in reducing maintenance costs themselves. Lower maintenance costs converts to greater maintenance productivity.

Furhermore, proper and timely servicing of equipment is important in preserving good operating characteristics in equipment.

A particularly sensitive area is lubrication. The right lubricant at the right time makes a significant contribution to the well-being of equipment. Replacement of filters and parts on a timely basis also contributes significantly to the continued good operation of equipment, as well as improved use of energy resources.

Odd Jobs

Even small emergencies and service calls (DIN Jobs - "Do It Now") and other unscheduled work are controlled and accounted for through the Maintenance Management and Improvement Program. This work is primarily of jobs of one hour or less. Response is controlled through two-way communication which puts maintenance men at the trouble spot virtually instantaneously. This allows equipment to be returned to "on-line" duty quickly. Computer records immediately identify lack of response.

Work costs are controlled through standards especially designed for small emergencies and service calls. An abbreviated version of the work is reported to the computer and is posted to the equipment history.

Equipment Stories

By using the computer to automatically update work history on each piece of equipment, a means to spot high maintenance-cost equipment is instantly available. Trouble equipment and bad components can be tracked and identified by equipment. Equipment on which corrective steps (i.e., installation of better components) should be taken can be seen quickly, and work can be done to correct on-going problems.

All costs for work on a given piece of equipment are kept on file. This history is then available for Discounted Cash Flow, Rate of Return or other analysis when replacement "signals" for equipment begin to show. Valid comparisons with replacement equipment can be made.

Effect on Morale?

With hours and dollars pin-pointed for all levels of management, "achievers" are high-lighted, as are under-achievers. Based on facts, recognition for outstanding work can be given, and steps taken to assist those who have been failing to measure up. With everyone measured equally, and equally treated by the facts, morale of those who do good work increases when they become recognized for their conscientiousness. The complaint that "no one knows how much we do," quoted often in maintenance meetings everywhere, no longer goes unanswered.

Early Steps

The practical side of effective maintenance says that equipment must be in good shape before any preventive maintenance program can really reach top efficiency. A reconditioning program is generally needed to put equipment back in to top condition. Such reconditioning is an integral part of the Maintenance Management and Improvement Program - the initial step toward a low-cost, efficient maintenance effort. Such reconditioning takes some time and is provided for in the initial phases of the program.

Also needed is time for people to adjust to the new program. New ideas and concepts must be learned, and time provided for this learning. Training and time to learn the preventive maintenance steps is needed to allow the program to come up to "speed."

Lasting Effects

Sharply-increased levels of productivity of men and equipment result fom the Maintenance Management and Improvement Program.

Better inventory planning not only provides improved control and reduced costs of inventory, but also reduces downtime and "out-of-service" equipment while parts and materials are being "scrambled" for. In sum, work is done in a more orderly fashion with better organization of necessary tools and materials.

Accountability is, often for the first time, pinned down by department, area, building and even to each piece of equipment and to each work directive. Managers are now able to identify where hours and dollars are being spent, not only for control purposes, but also for diagnostic purpose.

With accountability, better budgeting for future work can easily be achieved. Hours and dollars needed for various skills, areas of effort and types of work can now be identified and readily summarized for use in budget preparation.

Reduced maintenance costs from more effective utilization of people, minimal overtime and substantial reduction in material costs due to a sharp decrease in "emergency" work, impacts directly on unit output costs.

With equipment breakdowns reduced to a bare minimum, many more units of output are achieved by equipment that keeps running steadily. This results in a greatly reduced cost-per-unit output. This is even more emphasized when the greater output effect is combined with drastically-reduced maintenance costs.

Not only maintenance costs, but energy costs, are also reduced when equipment is kept in top shape. This, of course, decreases the cost-per-unit of output even more.

A side effect, but just as important, is the increase in consistency of quality. Equipment maintenance, when performed within strict limits, is bound to produce more consistent quality of results. In addition, equipment in good shape is not going to cause waste, or downtime periods at anything near the levels of poorly-maintained equipment.

And remember, whether a building complex has as its mission the education of students, medical care of the ill, or the support of administrative offices, downtime is a measurable statistic that affects the overall cost effectiveness of the organization.

TABLE 1

Syska & Hennessy's

FACILITIES MANAGEMENT
INFORMATION SYSTEM

This program provides the following CRT (Cathode Ray Tube) Screen Displays and Management Reports and operates on main frame, mini and micro computers.

CRT SCREEN DISPLAYS

Menu of Displays Available

Component Name Plate Record Information
(Screen No. 1)

PM Work Order Information
(Screen No. 2)

Spare Parts
(Screen No. 3)

Descriptive Codes

Work Order Maintenance Screen

Work Order History Screen

Inventory Data Maintenance Screen

Report Request Data Screen

Control Menu

Alpha Designation Data

Location Data

Password Data

MANAGEMENT REPORTS

PM (Preventive Maintenance) Work Order Issued Report

Sample PM Work Order

PM Work Order Status Report

Labor Efficiency Report

Cost Control Report

Open Work Order Status Report

Closed Work Order Status Report

DIN ("Do It Now") Work Report

Delinquent Work Order Report

MSI (Maintenance Significant Item) Nameplate Data Listings

Descriptive Code Data Listings

Alpha Designation Listings

MSI Work Order History Report

MSI Index

MSI – Building Index

MSI – Work Order Index

PM Work Order Schedule Report

Inventory Reorder Report

COMPUTER FLOW DIAGRAM I

DATA ENTRY AND PRINTING OF PM WORK ORDERS

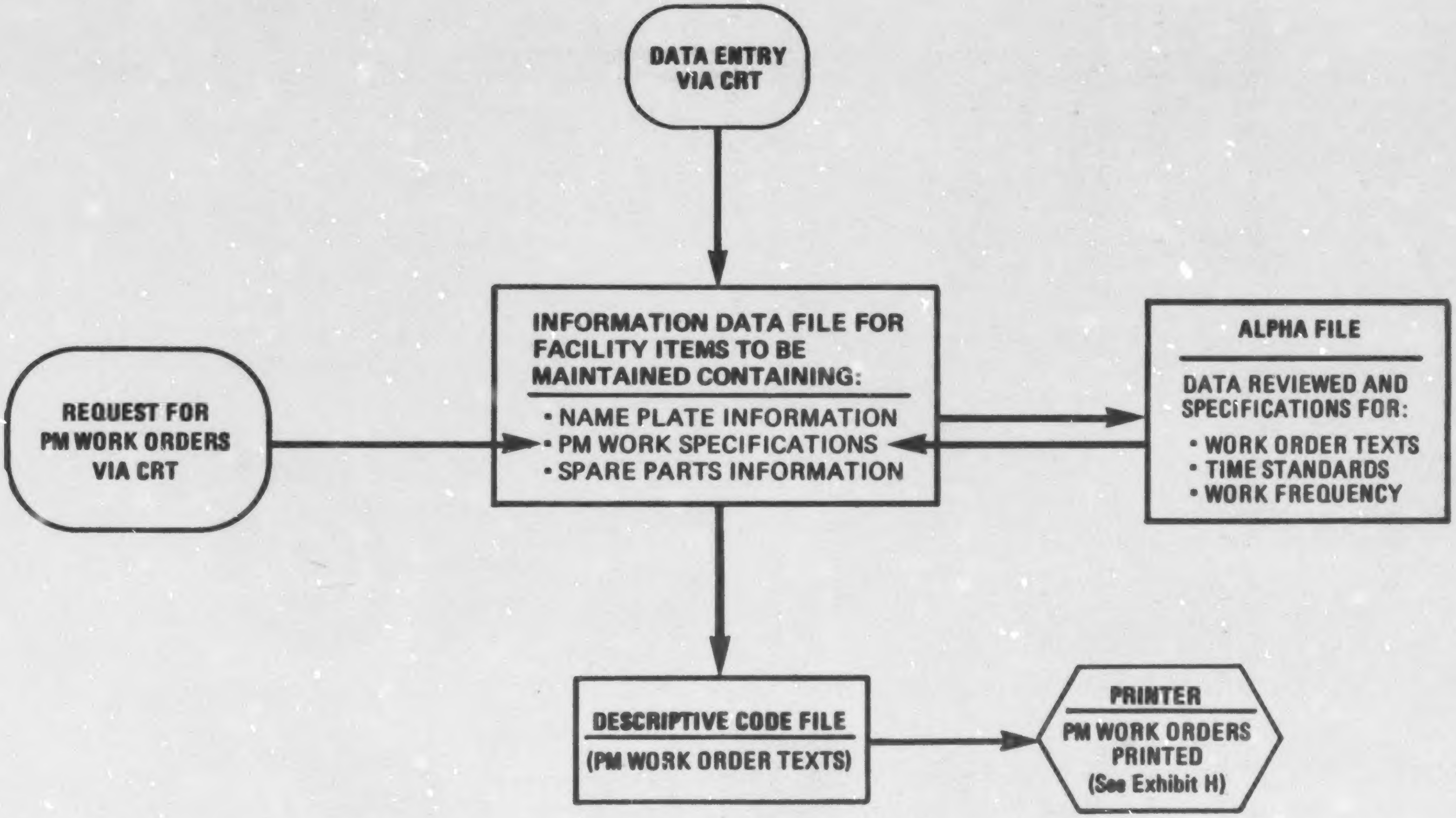
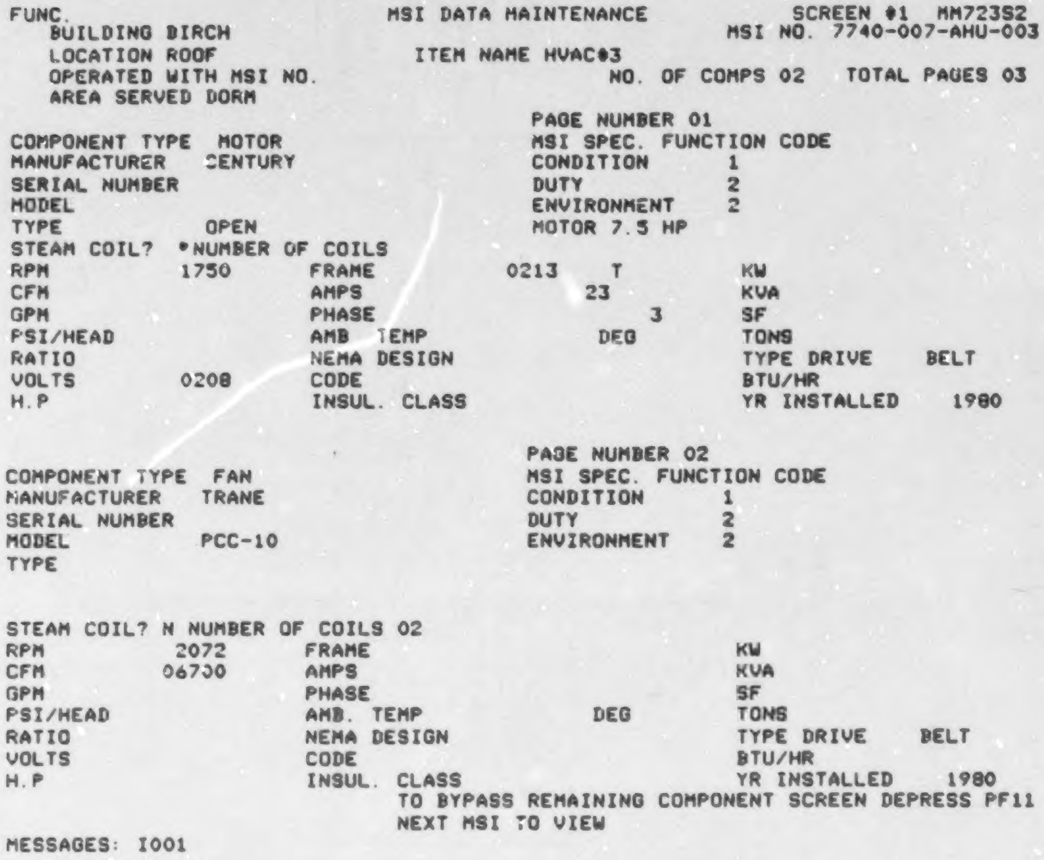


Exhibit A

TWO SAMPLES OF CRT SCREEN NO. 1
(COMPONENT NAME PLATE RECORD INFORMATION)



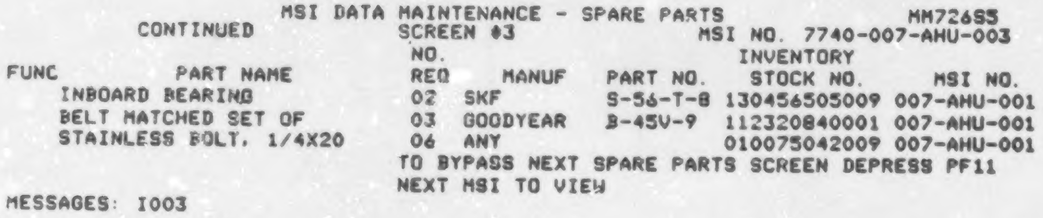
```
FUNC.                        MSI DATA MAINTENANCE         SCREEN #1  MM723S2
   BUILDING BIRCH                                       MSI NO. 7740-007-AHU-003
   LOCATION ROOF                ITEM NAME HVAC#3
   OPERATED WITH MSI NO.                       NO. OF COMPS 02   TOTAL PAGES 03
   AREA SERVED DORM
                                            PAGE NUMBER 01
COMPONENT TYPE  MOTOR                       MSI SPEC. FUNCTION CODE
MANUFACTURER   CENTURY                      CONDITION       1
SERIAL NUMBER                               DUTY            2
MODEL                                       ENVIRONMENT     2
TYPE           OPEN                         MOTOR 7.5 HP
STEAM COIL?  *NUMBER OF COILS
RPM          1750      FRAME          0213    T          KW
CFM                    AMPS                23            KVA
GPM                    PHASE                   3         SF
PSI/HEAD               AMB  TEMP           DEG           TONS
RATIO                  NEMA DESIGN                       TYPE DRIVE    BELT
VOLTS        0208      CODE                              BTU/HR
H.P                    INSUL. CLASS                      YR INSTALLED    1980

                                            PAGE NUMBER 02
COMPONENT TYPE  FAN                         MSI SPEC. FUNCTION CODE
MANUFACTURER   TRANE                        CONDITION       1
SERIAL NUMBER                               DUTY            2
MODEL          PCC-10                       ENVIRONMENT     2
TYPE

STEAM COIL? N NUMBER OF COILS 02
RPM          2072      FRAME                             KW
CFM          06730     AMPS                              KVA
GPM                    PHASE                             SF
PSI/HEAD               AMB. TEMP           DEG           TONS
RATIO                  NEMA DESIGN                       TYPE DRIVE    BELT
VOLTS                  CODE                              BTU/HR
H.P                    INSUL. CLASS                      YR INSTALLED    1980
                           TO BYPASS REMAINING COMPONENT SCREEN DEPRESS PF11
                           NEXT MSI TO VIEW
MESSAGES: I001
```

Exhibit B

SAMPLE OF SCREEN NO. 3
(SPARE PARTS INFORMATION)



```
                   MSI DATA MAINTENANCE - SPARE PARTS                MM726S5
        CONTINUED          SCREEN #3               MSI NO. 7740-007-AHU-003
                            NO.                          INVENTORY
FUNC          PART NAME     REQ     MANUF    PART NO.    STOCK NO.      MSI NO.
    INBOARD BEARING         02  SKF          S-56-T-8  130456505009 007-AHU-001
    BELT MATCHED SET OF     03  GOODYEAR     B-45V-9   112320840001 007-AHU-001
    STAINLESS BOLT, 1/4X20  06  ANY                    010075042009 007-AHU-001
                           TO BYPASS NEXT SPARE PARTS SCREEN DEPRESS PF11
                           NEXT MSI TO VIEW
MESSAGES: I003
```

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Exhibit C

OPEN WORK ORDER STATUS REPORT

DATE 10/28/82 - PAGE 1

FROM 09/03/82 TO 10/22/32

Due Date	Issue Date	Work Order No.	--Status--	MSI NO.	Estimated Hours	Estimated Labor $	Estimated Materials $	Actual Hours	Actual Labor $	Actual Materials $
11/01/82	10/08/82	AE000001	IN PLANNING	7740-014-SPF-001	20.0	200.00	.00	.0	.00	.00
11/01/82	10/08/82	AE000002	IN PLANNING	7740-017-CAC-001	20.0	200.00	.00	.0	.00	.00
			TOTAL FOR WORK ORDER TYPE AE		40.0	400.00	.00	.0	.00	.00
10/15/82	10/01/82	ME000012	IN PLANNING	7740-001-AHU-001	10.0	100.00	50.00	.0	.00	.00
10/12/82	10/02/82	ME002630	IN PLANNING	7740-003-CWP-003	15.0	150.00	700.00	.0	.00	.00
			TOTAL FOR WORK ORDER TYPE ME		25.0	250.00	750.00	.0	.00	.00
			TOTAL FOR IN PLANNING STATUS		65.0	650.00	750.00	.0	.00	.00
11/01/82	10/08/82	AE000003	AWAITING MA	7740-017-CRP-001	20.0	200.00	100.00	.0	.00	.00
11/01/82	10/08/82	AE000004	AWAITING MA	7740-017-CRP-002	20.0	200.00	150.00	.0	.00	.00
			TOTAL FOR WORK ORDER TYPE AE		40.0	400.00	250.0	.0	.00	.00
10/22/82	10/05/82	MM003740	AWAITING MA	7740-007-SAF-002	16.0	160.00	175.00	.0	.00	.00
10/31/82	10/20/82	MM001234	AWAITING MA	7740-010-RAF-003	10.0	100.00	75.00	.0	.00	.00
			TOTAL FOR WORK ORDER TYPE MM		26.0	260.00	250.00	.0	.00	.00
			TOTAL FOR AWAITING MATERIAL STATUS		66.0	660.0	500.00			
10/21/82	10/08/82	AE000005	TO BE SCHED	7740-023-WAU-001	20.0	200.00	75.00	.0	.00	.00
11/01/82	10/08/82	AE000006	TO BE SCHED	7740-023-WAU-002	20.0	200.00	175.00	.0	.00	.00
			TOTAL FOR WORK ORDER TYPE AE		40.0	400.00	250.00	.0	.00	.00
10/31/82	10/15/82	MM000013	TO BE SCHED	7740-014-AHU-003	16.0	320.00	700.00	.0	.00	.00
11/15/82	10/27/82	MM000014	TO BE SCHED	7740-015-AHU-003	16.0	320.00	700.0	.0	.00	.00
			TOTAL FOR WORK ORDER TYPE MM		32.0	640.0	1400.00	.0	.00	.00
			TOTAL FOR TO BE SCHEDULED STATUS		72.0	1040.0	1650.00	.0	.00	.00

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COMPUTER FLOW DIAGRAM II

UPDATE OF WORK ORDER INFORMATION AND PRODUCTION OF RELATED REPORTS

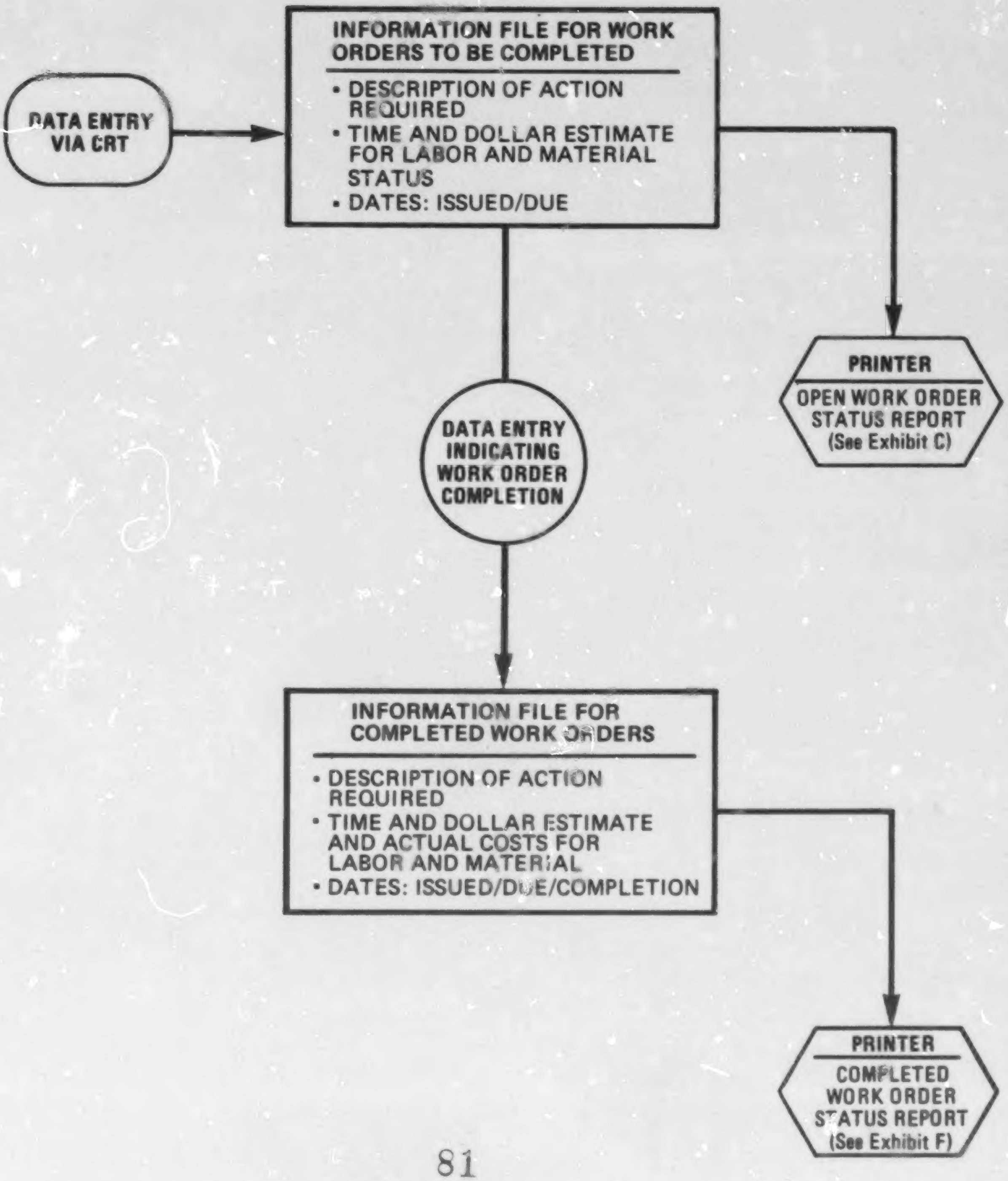
DATA ENTRY VIA CRT
INFORMATION FILE FOR WORK ORDERS TO BE COMPLETED
• DESCRIPTION OF ACTION REQUIRED
• TIME AND DOLLAR ESTIMATE FOR LABOR AND MATERIAL STATUS
• DATES: ISSUED/DUE
PRINTER
OPEN WORK ORDER STATUS REPORT (See Exhibit C)
DATA ENTRY INDICATING WORK ORDER COMPLETION
INFORMATION FILE FOR COMPLETED WORK ORDERS
• DESCRIPTION OF ACTION REQUIRED
• TIME AND DOLLAR ESTIMATE AND ACTUAL COSTS FOR LABOR AND MATERIAL
• DATES: ISSUED/DUE/COMPLETION
PRINTER
COMPLETED WORK ORDER STATUS REPORT (See Exhibit F)

Exhibit D

PM WORK ORDERS ISSUED STATUS REPORT

REPORT NO. V01

FOR WEEK NUMBER 41

RETURN BY FRIDAY OF WEEK NUMBER 42

DATE 10/28/82
PAGE NO. 1

WORK ORDER NO.	MSI NO.	LOCATION	ESTIMATED HOURS	COMMENTS
PU410001	7740-001-EEL-001	CENTER	0004.1	
PU410002	7740-001-EEL-002	MALE SIDE	0004.1	
PU410003	7740-001-EEL-003	F SIDE	0004.1	
PU410004	7740-002-DYR-001	CENTER	0002.0	
PU410005	7740-002-DYR-002	NW WALL	0002.0	
PU410006	7740-002-DYR-003	CENTER	0002.0	
PU410007	7740-002-DYR-004	STAFF ROOM	0002.0	
PU410008	7740-002-DYR-005	STAFF ROOM	0002.0	
PU410009	7740-002-DYR-007	STAFF ROOM	0002.0	
PU410010	7740-002-DYR-008	CENTER	0002.0	
PU410011	7740-002-EXT-001	BETWEEN WASHERS	0002.0	
PU410012	7740-002-FIR-001	WEST WALL	0002.0	
PU410013	7740-002-FIR-002	WEST WALL	0002.0	
PU410014	7740-002-FIR-003	WEST WALL	0002.0	
PU410015	7740-002-FIR-004	NE WALL	0002.0	
PU410016	7740-002-FIR-005	WEST WALL	0002.0	
PU410017	7740-002-FIR-006	NE WALL	0002.0	
PU410018	7740-002-FLD-001	WEST WALL	0002.0	

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Exhibit E

COST CONTROL REPORT

```
REPORT NO. M35                                                                                              DATE 10/28/82

                                                                   FROM  09/03/82 TO 10/22/82              PAGE NO.   3

                                                                                   -------------ACTUAL-------------        TOTAL
          BUILDING                      TYPE OF WORK   MSI NO.        LOCATION       HOURS     LABOR $    MATERIAL $        COST $
        . --------                      ------------   -------        --------       -----     -------    ----------        ------
WILLOW                                   PREVENTIVE   022-GEF-001   MECH RM            3.0        0.00          0.00          0.0
WILLOW                                   PREVENTIVE   022-GEF-002   MECH RM            3.5        0.00          0.00          0.0
WILLOW                                   PREVENTIVE   022-SAF-001   MECH RM            4.0        0.00          0.00          0.0
WILLOW                                   PREVENTIVE   022-WSP-001   MECH RM            3.9        0.00          0.00          0.0
WILLOW                                   PREVENTIVE   022-WSP-002   MECH RM            4.0        0.00          0.00          0.0
       ........            BUILDING TOTALS                                            38.4      400.00         50.00        450.0

POPLAR                                   PREVENTIVE   023-CAC-001   MECH RM            5.0        0.00          0.00          0.0
POPLAR                                   PREVENTIVE   023-CRP-001   MECH RM            7.0        0.00          0.00          0.0
POPLAR                                   PLAN MAINT   023-CRP-001   MECH RM           30.0      600.00        900.00       1500.0
POPLAR                                   PREVENTIVE   023-CRP-002   MECH RM            6.0        0.00          0.00          0.0
POPLAR                                   PLAN MAINT   023-WAU-010   RM 7              25.0      500.00        200.00        700.0
       ........            BUILDING TOTALS                                            73.0     1100.00       1100.00       2200.0

TUNNEL                                   PLAN MAINT   047-GEF-001   MAIN TO IVY       10.0      200.00        100.00        300.0
TUNNEL                                   PLAN MAINT   047-GEF-002   IVY TO LARCH      15.0      300.00        150.00        450.0
       ........            BUILDING TOTALS                                            25.0      500.00        250.00        750.0

....... GRAND TOTALS .................                                               420.5     4472.00       1493.00       5962.0
```

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Exhibit F

CLOSED WORK ORDER STATUS REPORT

```
                                                                          FROM  09/03/82  TO  10/22/82

                                                                 ----------Estimated-----------       ---------Actual-----------------
  Due          Issue           Work       --Status--       MSI NO.        Hours    Labor $    Materials $      Hours    Labor $     Materials $
  Date         Date          Order No.

10/15/82     09/01/82        AE000035     COMPLETED    7740-002-SAF-001   16.0     320.00      100.00          14.0     280.00         70.00
10/16/82     09/05/82        AE000039     COMPLETED    7740-002-CAH-003   24.0     480.00      150.00          25.0     500.00        150.00

                                  TOTAL FOR WORK ORDER TYPE AE            40.0     800.00      250.00          39.0     730.00        220.00

10/22/82     09/30/82        ME000045     COMPLETED    7740-002-IAF-G01   12.0     240.0        75.0            8.0     160.00        100.00

                                  TOTAL FOR WORK ORDER TYPE ME            12.0     240.0        75.0            8.0     160.00        100.00

10/20/82     09/29/82        MM000049     COMPLETED    7740-003-AHU-004   16.0     320.0       150.00          16.0     320.00        160.00
10/18/82     10/01/82        MM000055     COMPLETED    7740-004-SAF-007   24.0     480.0       175.00          20.0     400.00        180.00

                                  TOTAL FOR WORK ORDER TYPE MM            40.0     800.00      325.00          36.0     720.00        340.00
                                  TOTAL FOR COMPLETED STATUS              92.0    1840.00      650.00          83.0    1610.00        660.00
                                                                          ====    =======      ======          ====    =======        ======

                                  STATUS TOTAL                           383.2    5390.00     4200.00          83.0    1610.00        660.00

                                                                 (Please note that this is an abbreviated example)
```

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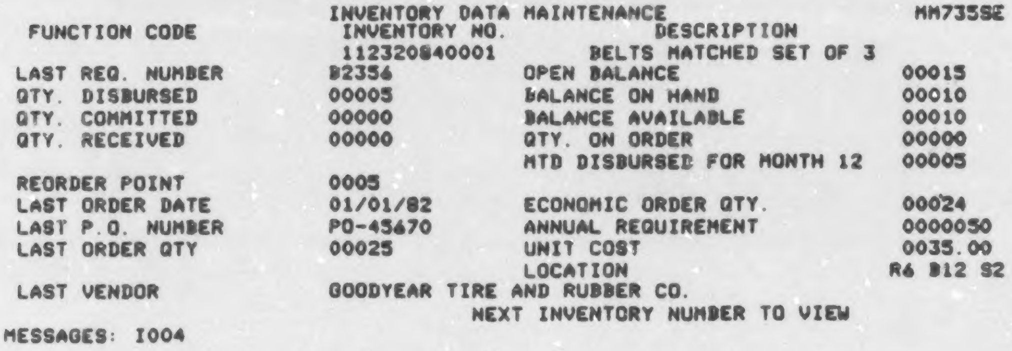
Exhibit G

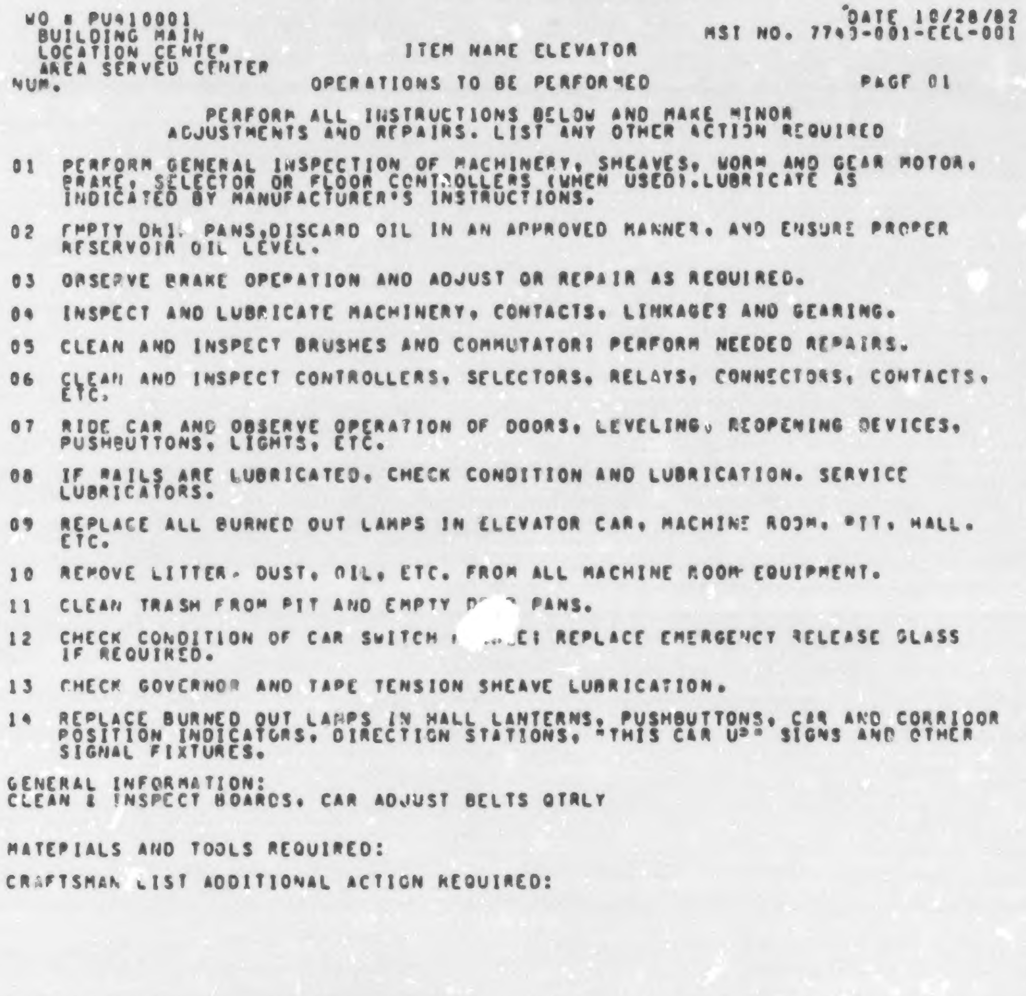
SAMPLE INVENTORY DATA MAINTENANCE SCREEN (MATERIAL AND SPARE PARTS INFORMATION)



```
                            INVENTORY DATA MAINTENANCE                MM735SE
 FUNCTION CODE               INVENTORY NO.         DESCRIPTION
                             112320840001     BELTS MATCHED SET OF 3
LAST REQ. NUMBER            B2356            OPEN BALANCE                00015
QTY. DISBURSED              00005            BALANCE ON HAND             00010
QTY. COMMITTED              00000            BALANCE AVAILABLE           00010
QTY. RECEIVED               00000            QTY. ON ORDER               00000
                                             MTD DISBURSED FOR MONTH 12  00005
REORDER POINT               0005
LAST ORDER DATE             01/01/82         ECONOMIC ORDER QTY.         00024
LAST P.O. NUMBER            PO-45670         ANNUAL REQUIREMENT          0000050
LAST ORDER QTY              00025            UNIT COST                   0035.00
                                             LOCATION                    R6 B12 S2
LAST VENDOR                 GOODYEAR TIRE AND RUBBER CO.
                                     NEXT INVENTORY NUMBER TO VIEW
MESSAGES: I004
```

Exhibit H

PREVENTIVE MAINTENANCE WORK ORDER



```
WO # PU410001                                              DATE 10/28/82
 BUILDING MAIN                                  MSI NO. 7743-001-EEL-001
 LOCATION CENTER              ITEM NAME ELEVATOR
 AREA SERVED CENTER
NUM.                  OPERATIONS TO BE PERFORMED               PAGE 01

             PERFORM ALL INSTRUCTIONS BELOW AND MAKE MINOR
          ADJUSTMENTS AND REPAIRS. LIST ANY OTHER ACTION REQUIRED

01   PERFORM GENERAL INSPECTION OF MACHINERY, SHEAVES, WORM AND GEAR MOTOR,
     BRAKE, SELECTOR OR FLOOR CONTROLLERS (WHEN USED).LUBRICATE AS
     INDICATED BY MANUFACTURER'S INSTRUCTIONS.

02   EMPTY OIL PANS,DISCARD OIL IN AN APPROVED MANNER, AND ENSURE PROPER
     RESERVOIR OIL LEVEL.

03   OBSERVE BRAKE OPERATION AND ADJUST OR REPAIR AS REQUIRED.

04   INSPECT AND LUBRICATE MACHINERY, CONTACTS, LINKAGES AND GEARING.

05   CLEAN AND INSPECT BRUSHES AND COMMUTATOR; PERFORM NEEDED REPAIRS.

06   CLEAN AND INSPECT CONTROLLERS, SELECTORS, RELAYS, CONNECTORS, CONTACTS,
     ETC.

07   RIDE CAR AND OBSERVE OPERATION OF DOORS, LEVELING, REOPENING DEVICES,
     PUSHBUTTONS, LIGHTS, ETC.

08   IF RAILS ARE LUBRICATED, CHECK CONDITION AND LUBRICATION. SERVICE
     LUBRICATORS.

09   REPLACE ALL BURNED OUT LAMPS IN ELEVATOR CAR, MACHINE ROOM, PIT, HALL,
     ETC.

10   REMOVE LITTER, DUST, OIL, ETC. FROM ALL MACHINE ROOM EQUIPMENT.

11   CLEAN TRASH FROM PIT AND EMPTY [illegible] PANS.

12   CHECK CONDITION OF CAR SWITCH [illegible]; REPLACE EMERGENCY RELEASE GLASS
     IF REQUIRED.

13   CHECK GOVERNOR AND TAPE TENSION SHEAVE LUBRICATION.

14   REPLACE BURNED OUT LAMPS IN HALL LANTERNS, PUSHBUTTONS, CAR AND CORRIDOR
     POSITION INDICATORS, DIRECTION STATIONS, "THIS CAR UP" SIGNS AND OTHER
     SIGNAL FIXTURES.

GENERAL INFORMATION:
CLEAN & INSPECT BOARDS, CAR ADJUST BELTS QTRLY

MATERIALS AND TOOLS REQUIRED:

CRAFTSMAN LIST ADDITIONAL ACTION REQUIRED:



WORK DONE BY ____________________  DATE ________   HRS. REQUIRED _____
```

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The Physical Plant Administrator's Role in Campus Master Planning

Dr. William J. Griffith
Bohm-NBBJ

The thesis of this paper is that the physical plant administrator at any college or university can and should have a major role to play throughout the process of campus master planning. This process covers all the activities necessary to chart a course for the future use and development of the capital resources of the institution—land and buildings plus the infrastructure of streets and roads, walkways, bikeways, trunk utilities and energy generation. The physical plant administrator (and appropriate members of the staff) is important to the campus master planning process whether the institution accomplishes this process as an ongoing activity by campus staff or whether it is done periodically using outside consultants.

All too often, however, the physical plant administrator is involved in campus master planning in a limited way or not at all. At one extreme, this activity is sometimes seen as an "academic" exercise which involves only faculty and academic administrators. Of course, campus master planning must be strongly dependent on academic program data and plans, which are its major driving force. Yet it cannot be a truly comprehensive process unless it deals fully with the "physical side" of the institution's capital resources. At the other extreme, campus master planning is sometimes viewed as an architectural and landscape planning and design process which should be handled by persons trained in these fields. Again, that is too narrow a view. Obviously these dimensions are important but they are only one facet of a many-sided problem.

In reality, campus master planning is neither predominantly "academic" nor "physical." It should cover all programs, not only instruction and instruction support but also all service programs needed by the institution, including those provided through the physical plant department.

Why Involve the Physical Plant Administrator?

One may cite at least four principal reasons why the physical plant administrator must play a significant role throughout the campus master planning process. They are obvious reasons, but they are often overlooked.

First, the physical plant department is both a provider of programs and services and a consumer of institutional resources. In this sense it is no different from an academic department. While it is true that the physical plant department is not directly involved in the primary mission of the campus (teaching, research, and public service), that mission cannot be accomplished without the services provided by the physical plant department. As a provider of very basic services to the primary programs, the physical plant department should have input into any development or redevelopment planning to insure that the basic services are adequately considered and provided for in institutional master plans.

Most physical plant administrators are all too familiar, however, with the institutional practice of preparing academic plans, recruiting faculty and staff, allocating operating funds, and then discovering that some facilities are required, either new or remodeled. The scope of such "oversights" can vary all the way from one faculty office to an entire suite of classrooms and laboratories. While it may not always be the physical plant department's responsibility to provide the space, or to see that needed remodeling is done, it will be its responsibility to care for and service the space whether budgeted for or not. Only by ongoing involvement of the physical plant administrator in institutional planning can such problems be averted.

The physical plant department is a major consumer of institutional resources. The care and maintenance of the physical plant and grounds can command ten to fifteen percent of the general funds budget depending on the scope of services provided. It is sheer folly not to involve in campus master planning the administrator of a service which has such effect on institutional operations.

Second, the physical plant administrator is responsible for the care and operation of a major share of institutional resources. In fact, for capital resources, physical plant is mainly responsible. One may argue that there are five principal categories of "usable" resources available to a college or university: the faculty, the library, the annual operating budget, all capital equipment, and the physical plant. To omit any of these categories from the campus master planning process would make no sense at all.

Third, the physical plant administrator is a major source of information, both current and projected, regarding the capital resources of the institution. The physical plant department is the prime source of much vital information that is essential to a comprehensive campus master planning process. Any such process must have reliable data about existing buildings, their overall condition, their improvement needs, their deferred maintenance problems, their energy use, and their safety and environmental quality. The same can be said for all underground utility lines, for campus vehicle and pedestrian ways, and to some extent for campus land. The best source of campus base maps is often physical plant. Of course, one could argue that such vital data can be collected for use from the physical plant. Indeed it can. But that would be a poor substitute for involvement of the department which is directly responsible for the information and which will understand both its meaning and its limitations.

Fourth, the physical plant administrator has useful knowledge which can contribute to resolution of problems and issues that must be faced in the campus master planning process. The physical plant department is frequently the best source of information regarding former campus land uses which may have serious implications for future building sites. Knowledge can often be located in physical plant department records about old dump sites or other lands fills, details about former building sites which may have had basements filled or have foundation walls remaining, or information about soil conditions from test bores or other excavations. Moreover, the physical plant department may be the best source of information about current campus land uses, especially on a campus where no regular campus planning office exists. Physical Plant may be a good source of information about campus traffic issues, especially since its vehicles must content with campus traffic daily. Such information, properly documented, is essential to campus master planning.

Doing campus master planning without regard to the plant operating cost of plans (as well as the capital cost) can be very foolhardy. However, too often we in higher education have done so. Yet good planning requires consideration of the likely impact of campus and facility plans on the general funds budget. That requires hard data on current costs for forecasting purposes. Clearly, the prime source for plant operation and maintenance data and for energy cost and use is the physical plant department. How viable is a campus master plan calling for X square feet of new facilities if the institution cannot reasonably muster the funds to maintain and operate them?

One would hope that long-range campus planning will consider quality standards for physical facilities which will pay attention to durability and maintainability of materials and surfaces, especially when the campus master plan includes a design vocabulary. What better source of information for quality standards than the physical plant department which must deal with durability and maintainability on a daily basis? This should apply both to buildings and to grounds.

Long-range campus planning should not only deal with future needs but also provide for solving current problems, especially those likely to become worse with further campus growth or development. The physical plant department is usually the best source of information about current problems with providing services to campus facilities. What are the problems with trunk utility systems--capacity, condition, area covered, etc? Where is storm water drainage a problem on campus? In what areas of campus are delivery of materials or removal of trash from buildings a problem? Where do service or emergency vehicles have difficulty maneuvering? What campus grounds areas are most difficult to maintain and why? These and similar problems should be addressed in a campus master plan process.

A Role for the Physical Plant Administrator in Campus Master Planning

In the most elementary model, campus master planning can be seen as a five-step process. A very definite role can be seen for the physical plant administrator in each step.

Step 1: Definition of capital resource needs. This step has two principal dimensions: programs definition (all programs to be provided by the institution) and populations definition (all populations to be served by the institution). This step is (or should be) the most vital of all because it provides the basic data from which capital resources needs may be defined. Again, in a very simplistic model, one may say that programs define the nature and quality of capital resources needs while populations define the quantity.

The program definition must be as comprehensive as possible. It must include not only the primary (academic) programs and plans of the institution but also all the service and support programs and plans. Thus, all the support services under the purview of the physical plant administrator must be part of this step. This includes plant operation and maintenance, of course, but should also cover grounds maintenance and building services, plus any other services assigned to physical plant. These will vary by institution, but need to be included whatever they are. Why are these service programs important to include in capital resources need definition? Because they have capital resource requirements. For example, grounds maintenance can be done without a facility for equipment storage and maintenance, but in the long pull it will cost the institution more. Therefore, any need for such facility should be part of long-range planning. A similar argument can be made for other services provided by the physical plant department. In reality this argument is no different from that for any academic support services such as library or teaching aids. If the service is to be provided the requisite capital resources must be planned for. Additionally, one must be realistic enough to recognize that service facilities are frequently less attractive so their location becomes very important to the overall campus plan.

Step 2: Analysis of capital resources. Once needs have been defined, the obvious next step is to assess the quality and quantity of existing capital resources--land, buildings, and campus infrastructure. Clearly the physical plant administrator is a major source of information for this analysis because that person can supply good data about current quality and condition of facilities, long-range improvement needs, and deferred maintenance problems. These data are vital because a comprehensive campus master plan cannot deal only with additional capital resources needs; it must deal also with the quality improvement needs of all existing capital resources which are to be continued in use.

However, the physical plant administrator's role in this step should not be limited only to providing data. It should include full partnership in decision-making about the future of existing capital resources because of the knowledge and professional judgement possessed by the physical plant administrator.

Step 3: Development of campus master plan concepts and principles. These are really the heart of the campus master plan process. They shape the plan around needs and resources. They deal with a wide variety of topics in such areas as campus access, land use, facility use standards, environmental quality, functional affinities, energy use and conservation, facility quality, design vocabulary, safety and security, time and travel distances, access and use by the physically impaired, and campus-neighborhood interface. The development of viable concepts and principles in these areas deserves wide participation by representative campus personnel. There is no doubt that the physical plant administrator must be a full participant in this process. That person can be especially helpful in such areas as quality criteria for campus buildings and facilities, land use criteria, and design vocabulary (scale, form, texture, color, material, etc.)

Step 4: Synthesis and testing of plan alternatives. In this step the planners formulate various alternative schemes for the campus master plan and test them against the planning concepts and principles established in Step 3. The physical plant administrator can be especially helpful in evaluating alternative schemes for their operational logistics. As the staff person responsible for several vital campus services, the physical plant administrator is uniquely qualified to advise which scheme(s) are most feasible logistically. Also, the knowledge and professional judgement of the physical plant administrator can be very useful in evaluating the economic feasibility of various schemes, particularly for the cost of operation and the extension of necessary utility services. Clearly, the commitment of an institution to a master plan without understanding the implications of annual operating costs would be poor management indeed. It may be that the institution will elect scheme B, which has higher annual operating cost potential, over scheme C because the former better meets plan concepts and principles. But that decision must be made with full knowledge of the cost implications and the physical plant administrator can assist with this analysis.

Step 5: Plan development. This step is in many respects a production job because most vital decisions will have been made. Yet there remains an important advisory and review role for the physical plant administrator who can 1) verify data, 2) review campus maps and other graphics for accuracy, 3) provide any needed supplemental information about existing capital resources, and 4) react to detailed plan recommendations as they are prepared.

Problems and Issues

Should the physical plant administrator be responsible for campus master planning or be a major participant in the process with administrative responsibility lodged elsewhere? It can be and is done either way. However, I will argue for the latter approach because I believe that campus master planning should be a continuous, not an occasional, process for which responsibility should be assigned to a staff officer responsible directly to the institution's chief executive officer. As a continuous process, it would likely consume an inordinate amount of the physical plant administrator's time if that person were chiefly responsible. Moreover, there are many problems and issues in campus master planning for which the physical plant administrator may not have the appropriate knowledge base or experience.

How can time be allocated by the physical plant administrator and staff for participation in campus master planning without jeopardizing ongoing operations? This could be a difficult problem, especially on a campus where long-range planning is an occasional exercise where everyone involved must allot time from regular duties. Usually the time comes "out of one's hide." If, however, campus master planning is a continuous process with a staff assigned the principal responsibility, then it is possible for others, such as the physical plant administrator, to budget time and to allocate staff assignments so that time can be regularly devoted to master planning. One would hope that this type participation is the method toward which institutions will strive.

Making Architects/Engineers Respond To Physical Plant Needs

By Dennis P. Cesari
University of Missouri

Every physical plant administrator who contracts for professional design and construction services requires effective procedures to work with architects and engineers to assure the college or university is receiving its full benefits from the consulting firm. This paper will identify the successful procedures that are used at the University of Missouri.

Contracting Consultant Services

One of the most important parameters which should be followed in obtaining well designed projects from architect/engineers (consultants) is to begin by hiring competent professionals. There are many well qualified professionals available to perform design work, however, most firms are not capable of doing every kind of design required. For instance, a civil engineering firm is not qualified to perform mechanical design as a mechanical engineering firm is not qualified to perform architectural design. It is imperative when reviewing consultant qualifications that their qualifications be reviewed for the specific project they are being considered for.

For institutions which hire many consulting firms each year, it is mandatory that consultant files be maintained which indicate the firms expertise and qualifications. A computerized file is maintained at the University of Missouri which lists firms in several different groupings in order to make information on the firms readily available. Each firm requesting to do work for the University is required to complete a questionnaire from which the data is entered into the computer. This consultant data file is then reviewed each time consulting services are required and the most qualified firm is then requested to submit a proposal for the project. (See Figures 1 and 2 for sample outputs from computer file.)

The consultant data file may also be used to collect a group of firms which will be interviewed for a large construction projects. Since most universities are public institutions, this file further serves as a means of justifying the selection of the most qualified firm.

Though most colleges and universities are public institutions, they are not required to bid consulting fees. Furthermore, consultants should never be selected based on their fee schedule. The cliché which states "you get what you pay for" is absolutely true when it comes to hiring consultants.

To assist physical plant administrators in negotiating consulting fees, files should be maintained for all projects indicating the names of the firms hired and the fees charged for the project. At the end of each year, a summary is provided at the University of Missouri which summarizes all the consultants hired during that year and the cost of their services. This information can then be used in negotiating future services and is a very effective negotiating tool.

The above procedures identified for listing consultants and summarizing fees annually has been approved by the Department of Energy as an acceptable means of hiring consultants for the Title III Grant Program. The Federal Government normally requests several proposals be received on each projects and, if possible, the consultant with the lowest fee be awarded the contract. This process, identified above, is much fairer to the consultants and requires less time for administrators.

The architects/engineers agreement which is used between the owner and the consultant is another area which requires an administrators attention. There are standard AIA agreements which can be used in addition to informal means, such as signing consultants proposals. It is, however, in the best interest of administrators to develop their own architect/engineer professional agreement.

The University of Missouri uses two basic professional type agreements. The first agreement, which is referred to as a "full A/E agreement", is for professional services required from design through construction (see Figure 3). The second agreement is referred to as a "letter agreement" and is used when consultants are hired only to perform feasibility studies (see Figure 4). The letter agreement is nothing more than a brief paragraph describing what's required of the consultant, the fee which will be paid to consultant, and a schedule which identifies the time line the work is to be completed. At the bottom of the form is the signature of the owner and the consultant.

The "full A/E agreement" used by the University of Missouri has several items which differ from the standard AIA agreement. Standard AIA agreements do not define the number of site visits required by the architect. It also indicates that architects are not responsible for existing conditions and are not required to check such. Consultants are not required to prepare as-builts as this burden is put upon the contractors. Schedules are not included in the A/E agreement and disputes are covered through arbitration.

The University of Missouri's agreement attaches two exhibits which clearly identify the scope, schedule, fees, and other important parameters of the project. The consultant is not allowed any reimbursables which can be clearly defined during the project conception. The agreement references University General Conditions and design guidelines and procedures manuals which, by this reference, require the consultant to conform to the University policies. The University agreement further requires the consultant to review all shop drawings within fourteen (14) days, rather than "reasonable time frame" as identified in the AIA agreement. The consultant is required to produce as-builts from marked-up blue lines provided by the contractor. It is to the best interest of the University to have professional prepare these as-builts as there is no way of telling what a contractor will provide in the way of as-builts. The University of Missouri does not recognize arbitration and, therefore, the Assistant Vice President for Business Services is identified as the individual within the University who will settle all disputes. If the consultant is not satisfied with this result, their option is always to file suit. The University's agreement also identifies energy budget levels when applicable for new construction.

Consultant Procedures and Design Guidelines

The next major area which should be addressed when hiring consultants is to have a means of informing the consultant of all University procedures, policies, design guidelines, and any other criteria which would prove beneficial to the consultant when designing a project. It is extremely difficult to consistently transmit this kind of information to consultants verbally on a project by project basis, if not in fact impossible. To provide the consultant with this information, the University of Missouri issues a manual titled "Consultants Procedures and Design Guidelines" at the conception of each project.

The "Consultants Procedures and Design Guidelines" manual is subdivided into three primary categories. Section I deals with consultant procedures and how the consultant is required to work with the University. Section II includes design criteria and Section III provides specification guidelines.

Section I In Section I, University and Consultant Procedures are identified which inform the professional on how to work within the University system. This type of information eliminates potential confusion for the consultants and directs them to receive information from a project coordinator within the University and no one else.

The first area in this section deals with project initiation and selection of consultants. This information is provided to give the consultant a general background into the University's hiring procedures.

The next areas in Section I deal with the contracting of consultants and the payment process. This area includes copies of the University A/E agreements and indicate to the consultant how he is to request payments for his services.

The next area deals with the design and review process which indicates what is expected of the consultant during this process and how the University interacts during this period. The bidding process and award of the construction contract are then reviewed and the consultant is informed of the procedures used during this process. The bidding process, for instance, includes information such the requirement of the consultant to prepare the bid tabulation form and attend the bid opening.

The construction process follows which further informs the consultant of all the procedures required of him and the University during the construction phase. Identified are the communication channels which are required by the University, which are that all communication to the contractor be made through the Owner's Representative. This eliminates misinformation being provided to the contractor from the consultant. Furthermore, the process which is used for change orders is clearly identified which requires all negotiations with the contractor be made through the owner's representative. Prior to this procedure, the consultant provided negotiations with contractors on change orders, which proved to be very unbeneficial to the University. In most cases, the professionals had no incentive to reduce contractors costs as they received percentage fees and, therefore, the higher the cost of the change order, the higher their fees would be. Thousands of dollars have been saved as a result of the implementation of this policy.

Section II Section II of the "Consultants Procedures and Design Guidelines" includes University design criteria. Covered in this area are six (6) major sections.

Energy guidelines are provided to the consultant which indicate budget levels for new buildings and minimum criteria for consideration on any project. The design process is outlined for the consultant as it pertains to the calculating of energy consumption of new facilities. Additional mechanical and electrical systems which relate to energy consumption are further discussed in Section III of the manual.

General design criteria is also listed in this section which identify items such as minimum number of janitor's closets required per floor with size indicated. Additionally, the requirement that each building be equipped with telephone rooms and other general information are included.

The next area includes drawing format. The drawing format indicates to the consultant items which are required to be shown on drawings and items which should not. Additionally, guidance is provided as to the types of symbols which should be used and the request that all work be segregated into disciplines, such as architectural work on architectural drawings and mechanical work on mechanical drawings, etc. The consultant is requested to cross reference all details on drawings and that all drawings be clear so they may be microfilmed.

The specification criteria section highlights the format for the specifications. The consultant is required to be clear in all specifications and not to be redundant when specifying items. Small drawings are not allowed in the specifications and are so indicated in this section. All this, and many other similar types of criteria, are provided in this section.

Code requirements for the University of Missouri are listed and the authority having jurisdiction defined. Consultants are required to obtain professional code consultants on all major projects and are required to review their analysis with the University.

The last area in this section includes a standard for floor and room numbering for all new and renovated facilities. A detailed format is provided which provides the consultant with the criteria of identifying room numbers properly on the plans.

97

Section III Section III of this manual includes specification guidelines. This section is basically subdivided into two areas, with the first being the front end or "boiler plate" and the second being the material systems preferences and requirements for Division 2 through 16 of the specifications.

The University of Missouri is very adamant about the format and the information provided in Division 1 of all specifications. This information is clearly identified in this section which includes the Advertisement for Bids, the Proposal for Lump Sum Contract, Bidder's Statement of Qualifications, Information for Bidders, General Conditions, Special Conditions, Index of Drawings, List of Alternates, and a copy of the University of Missouri Manufacturer's Certification and Roof Warranty.

A copy of the standard Proposal for Lump Sum Contract is included and the consultant is required to tailor the proposal for the project under design. The Advertisement for Bids is provided by the University and the consultant is required to insert it in the specifications. The Bidder's Statement of Qualifications, Information for Bidders, and General Conditions are preprinted and provided by the University.

The General Conditions used by the University of Missouri have been developed by the University and are not standard AIA or AGC General Conditions. This document is another critical document which should be reviewed by all administrators and modified to meet the needs of the college or university. Some of the AIA general condition items which should be reviewed closely are the following:

1. "All documents are the property of the architect and engineer."

2. "Architect/engineers are required to respond promptly.", with no definition of "promptly".

3. A paragraph is provided generally discussing warranties, but not specific as to minimum warranties.

4. Contractor's payments are discussed and included is a comment that if payments are not received within a specified period, interest will be charged.

5. Arbitration is allowed.

6. Substantial completion is defined loosely.

7. Change orders are discussed briefly and generally.

The University of Missouri's General Conditions (see Figure 5) are written specifically for the University of Missouri and the following are highlights of some pertinent areas:

1. All documents are the property of the University and not the architect/engineer.

2. A minimum of one (1) year warranty is listed for all equipment and, therefore, if a one year warranty is required, it does not have to be identified within the specifications.

3. The payment process is identified which does not allow the contractor to collect interest on payments. Furthermore, a process is identified which allows the contractor to claim material stored on site only if they identify that material before the project begins construction.

4. Arbitration is not allowed and the decision of the Assistant Vice President for Business Services is binding. Contractors have the right to file suit if not in agreement with his decision.

5. The term "substantial completion" is defined as the date which all punch list items are complete. This definition assists the University in obtaining completion of punch list items in an expedient manner.

6. The change order process is clearly identified as well as a maximum allowable contractor's overhead and profits on add and credit change orders.

Other items which differ from standard consultant's specifications is the inclusion of the University of Missouri Roof System Certification and Warranty. The University of Missouri requires their own roof system manufacturer's warranty be signed by the manufacturer for all roofing projects. This warranty is included in project specifications as well as the certification which is required to be signed by the manufacturer before the Notice to Proceed is issued. This certification certifies that the manufacturer will indeed sign the University's warranty at the completion of the project.

The remainder of Section III includes criteria for Divis[illegible] 2 through 16 of the specifications. This area of the manual does not [illegible] specifications for materials which the architect can copy and incorporate in his specifications but, rather, lists University preferences as they pertain to the work which would be specified in each construction division.

Division 2 incorporates requirements that top soil be stripped and stockpiled, trees should be preserved when possible, and that plant warranties are equal to 50% in value of the original price of the material. Asbestos removal is also discussed and the consultant is required to insert the University's Asbestos Removal Specifications if asbestos is going to be encountered during the construction.

Division 3 references concrete standards and also requires the consultant to only specify actual strength concrete required and not over designed unnecessarily. The consultant is also requested to indicate that contractors shall pay for all concrete testing and include such cost in their bid price. Other general concrete information is also included.

Divisions 4 through 6 include recommendations for masonry, metals, and woods and plastics such as the request that metal coping be used instead of coping stones on new buildings.

Division 7 of the manual does consist of detailed specifications which the architect can use as a guideline for roofing projects. Due to the experience the University of Missouri has had with single-ply roofing membranes, it was to the best interest of the University to provide this detailed information to the consultants. This section provides sample specifications for the three main single-ply systems which are loose-laid ballasted, mechanically fastened, and fully adhered.

Division 8 incorporates type of locking system used on all University buildings as well as the request that power assisted doors be provided at handicapped entrances. Division 9 requires the consultant to label all piping and provides a table for standard letter sizes and Division 10 through 14 indicate miscellaneous items applicable to each section.

Since a large portion of the cost and design options for each project are included in Division 15 - Mechanical, this section is the largest and incorporates many University preferences and requirements. Some of the most important items listed include the requirement that electrical heating systems not be used, that chilled water systems be used if possible, that reheating systems not be used, minimum air conditioner efficiencies are identified, type of pipe is identified for each utility service, minimum insulation for ductwork and piping are provided, and the requirement that meters be are provided for all utilities.

Division 16 - Electrical is also lengthy and incorporate minimum lighting standards which are listed by watts per square foot. Additionally, the requirement that electric demand energy meters are to be provided for all projects is included.

The above are extremely brief summaries of the information contained in Divisions 2 through 16. The important point for all administrators is that this information should be written down and provided to all consultants.

Physical Plant Review

Even with the best consultant's procedures and design guidelines provided to the consultant, it is ultimately the physical plant administrators responsibility to review the design work completed by the consultant. It is imperative the physical plant administrator have on staff competent architects, engineers, or service people who fully understand the drawings and specifications provided by the consultant. Even the best consultants constantly make numerous errors and, even with the best consultants procedures manual, items may be left out. The people that best know university facilities are the physical plant personnel and they should be involved in the review process. Physical plant administrators who trust engineers on projects such as energy conversions and do not review detailed sequences of operations and proposed systems operations will more than likely have failures after the project is completed.

Additionally, all the best designs in the world are of little value if the projects are not followed through properly during the construction process. The University of Missouri has on hand a full staff of project inspectors that work with the contractors daily on every construction project. Without these people, contractors constantly try to cover up mistakes and get by as cheap as possible, especially on public bid type projects.

In summary, the recipe for successful construction projects includes the hiring of competent professionals, providing the professionals with pertinent information, reviewing all work performed by the professional, and following all work through construction. Following this process will greatly increase the chances of having well designed and constructed projects.

FIGURE 1

```
                                                                                               17:26 THURSDAY, FEBRUARY 2, 1984


FIRM NAME AND ADDRESS
                                                                                                     SERVICES OFFERED
ABEND SINGLETON ASSOCIATES INC.           PHONE NUMBER:  816/221-5011
20 WEST NINTH STREET                      NAME OF CONTACT:  E. CRICHTON SINGLETON, AIA      X ARCHITECTURAL       STRUCTURAL ENG
KANSAS CITY, MISSOURI  64105                                                                                  MECHANICAL ENG
                                          # STAFF PROFESSIONALS:  17                        X INTERIOR DESIGN     CIVIL ENG
                                          MARKET AREA:  KANSAS CITY                         X LANDSCAPING         ELECTRICAL ENG
                                          LAST UPDATE OF INFORMATION:  06/81

TOTAL # CONTRACTS AWARDED:     5
TOTAL PROJECT AMOUNT AWARDED:      $568,000



PROJECT/INTERVIEW INFORMATION - CLASSROOMS                            PROJECT/INTERVIEW INFORMATION - STUDENT UNIONS-RESTAURANTS

PROJECT EXPERIENCE:   $2,000,000 - $4,999,999                         PROJECT EXPERIENCE:   $1,000,000 - $1,999,999
TOTAL # OF PROJECTS:   5                                              TOTAL # OF PROJECTS:   1

PROJECT/INTERVIEW INFORMATION - OFFICE BUILDINGS                      PROJECT/INTERVIEW INFORMATION - GYMS-STADIUMS-ATHLETIC FAC.

PROJECT CAPABILITY:   $2,000,000 - $4,999,999                         PROJECT EXPERIENCE:   $5,000,000 AND OVER
TOTAL # OF PROJECTS:   5                                              TOTAL # OF PROJECTS:   2

PROJECT/INTERVIEW INFORMATION - MEDICAL CLINICS

PROJECT EXPERIENCE:   $1,000,000 - $1,999,999
TOTAL # OF PROJECTS:   1

PROJECT/INTERVIEW INFORMATION - RADIO-TELEVISION

PROJECT EXPERIENCE:   $500,000 - $999,999
TOTAL # OF PROJECTS:   2

PROJECT/INTERVIEW INFORMATION - AUDITORIUMS-THEATRES-MUSEUMS

PROJECT EXPERIENCE:   $0 - $499,999
TOTAL # OF PROJECTS:   2

PROJECT/INTERVIEW INFORMATION - DORMITORIES

PROJECT EXPERIENCE:   $2,000,000 - $4,999,999
TOTAL # OF PROJECTS:   5
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FIGURE 2

SAS 17:2

PROJECT TYPES: PROJECT EXPERIENCE (NUMBER OF PROJECTS)

S= STUDY
1= BELOW $ 500,000
2=$ 500,000-$ 999,999
3=$1,000,000-$1,999,999
4=$2,000,000-$4,999,999
5=$5,000,000 AND ABOVE

MARKET: KANSAS CITY
FIRM TYPE: A/E FIRM

FIRM NAME	AUDITOR	CLASS ROOMS	CLINIC	DORMS	ENERGY	GYMS	HOSPITAL	LIBRARY	OFFICE	PARKING	POWER PLANT	RADIO T V	ROADS	ROOFS	SCIENCE BLDGS	STUDENT UNION	UTILITY DISTRIB	OTHER
ASSOCIATED ENGINEERS, INC.	( )	3(3)	( )	( )	( )	2(1)	1(1)	( )	1(5)	1(3)	( )	( )	2(3)	1(1)	2(4)	( )	3(4)	( )
BLACK & VEATCH	( )	4(2)	( )	5(1)	0(1)	( )	( )	( )	5(5)	( )	5(1)	4(1)	( )	0(3)	5(2)	( )	5(3)	5(4)
BUCHER & WILLIS	5(5)	5(3)	5(5)	5(5)	5(4)	5(5)	4(5)	2(4)	5(3)	2(3)	( )	1(1)	5(5)	5(1)	3(1)	5(3)	5(3)	( )
BURNS & MCDONNELL	( )	4(5)	( )	3(5)	5(4)	2(5)	1(1)	( )	5(5)	( )	5(5)	( )	5(5)	2(5)	5(2)	( )	5(4)	( )
GEORGE BUTLER ASSOCIATES	5(4)	5(4)	5(4)	5(5)	5(5)	5(4)	5(4)	2(3)	5(4)	5(5)	3(2)	3(1)	5(5)	5(1)	5(4)	5(4)	5(5)	( )
BOB D. CAMPBELL AND CO., INC.	1(3)	1(5)	1(1)	1(3)	( )	1(5)	1(5)	1(2)	1(5)	( )	1(2)	( )	( )	1(1)	1(1)	1(1)	( )	1(1)
CHAMPLIN ARCHITECTS	( )	( )	5(2)	( )	( )	( )	5(3)	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	4(4)
CIVIC ASSOCIATES, INC.	( )	( )	5(1)	1(1)	1(1)	2(2)	( )	( )	5(5)	( )	( )	( )	4(1)	1(1)	4(3)	3(1)	2(5)	( )
CROWLEY, WADE, MILSTEAD, INC.	( )	( )	5(1)	( )	( )	( )	( )	( )	( )	( )	( )	( )	5(2)	2(1)	( )	( )	5(3)	( )
JOHN LAWRENCE DAW & ASSOCIATES	1(1)	5(4)	4(3)	2(1)	2(1)	5(4)	5(3)	( )	5(3)	5(3)	( )	( )	2(2)	2(3)	5(2)	3(2)	( )	5(2)
DEVINE ARCHITECTS, INC.	4(2)	3(5)	3(5)	3(5)	4(2)	5(5)	4(5)	4(3)	4(5)	( )	( )	( )	4(3)	1(2)	3(1)	3(5)	( )	( )
HNTB, ARCHITECTS/ENGINEERS, PLANNERS	4(5)	5(5)	5(5)	5(5)	( )	5(5)	5(5)	( )	5(5)	5(4)	5(4)	5(1)	5(5)	( )	4(5)	( )	3(4)	( )
H.H. JOHNSON AIA ARCHITECT	3(5)	5(2)	2(1)	5(2)	2(1)	3(3)	1(2)	( )	5(5)	( )	( )	( )	4(5)	2(2)	( )	5(2)	( )	2(2)
LUNDEEN, JACK AND MASLAN	5(2)	( )	( )	5(1)	( )	3(1)	1(2)	( )	5(1)	( )	5(3)	( )	( )	5(2)	( )	5(1)	( )	5(5)
MARSHALL & BROWN	3(1)	5(5)	4(5)	5(2)	1(5)	( )	5(5)	3(1)	5(5)	5(5)	( )	( )	3(2)	2(4)	( )	3(2)	( )	5(5)
MASSAGLIA, NEUSTROM, BREDSON, INC.	5(3)	5(5)	5(3)	5(4)	5(5)	5(5)	5(5)	3(4)	5(4)	5(3)	( )	5(4)	( )	( )	5(5)	5(3)	5(3)	( )
PECKHAM GUYTON ALBERS & VIETS, INC.	5(5)	5(4)	5(4)	5(4)	5(0)	5(5)	5(5)	5(2)	4(5)	5(5)	( )	5(5)	5(1)	5(2)	5(5)	5(5)	5(4)	( )
THE RAMOS GROUP	4(3)	2(1)	( )	5(1)	5(1)	( )	( )	( )	5(5)	5(2)	( )	( )	( )	3(1)	( )	3(2)	( )	2(1)
HERMAN A. SCHARHAG CO., ARCHITECTS	( )	( )	4(3)	( )	( )	( )	4(1)	( )	4(3)	( )	( )	( )	( )	( )	( )	3(1)	( )	( )
SCHLUP, BECKER & BRENNAN, P.A.	( )	( )	1(1)	2(2)	5(4)	( )	3(1)	( )	3(4)	1(1)	5(1)	( )	5(5)	( )	3(4)	( )	3(4)	5(2)
TALIAFERRO AND BROWNE	1(1)	4(2)	1(5)	( )	( )	2(1)	( )	( )	( )	5(2)	( )	( )	5(5)	( )	1(2)	( )	5(5)	( )

87

FIGURE 3

UNIVERSITY OF MISSOURI
ARCHITECT/ENGINEER AGREEMENT
Revised 9/23/83

This agreement made and entered into this day of , 1983, by and between THE CURATORS OF THE UNIVERSITY OF MISSOURI, a public corporation of the State of Missouri, Owner, and ,Consultant.

WITNESSETH:

WHEREAS, Owner intends to hereinafter called "the project", and as more particularly described in the Project Description contained in Exhibit A attached hereto and incorporated by reference, and desires to employ the Consultant to perform professional services in respect thereto and as hereinafter set forth:

NOW, THEREFORE, the Owner and the Consultant for the considerations hereinafter named, agree as follows:

1. The Consultant agrees to perform professional services for the above-named project per the Project Description (Exhibit A) and as hereinafter set forth in Article 1.

2. The Owner agrees to pay the Consultant for such services as set forth in the Project Description, (Exhibit A) and as hereinafter defined, including other payments and reimbursements as hereinafter provided, the said fee being hereinafter called the "Basic Rate".

3. The parties hereto agree to the following terms and conditions:

ARTICLE 1
CONSULTANT'S SERVICES AND RESPONSIBILITIES

BASIC SERVICES

The Consultant's Basic Services consist of the phases described as follows and include where applicable, but are not limited to, architectural, structural, mechanical and electrical engineering services. The Consultant shall obtain approval of the Owner before proceeding with each phase. The phases in which the Basic Service is to be provided are as follows:

1.1 SCHEMATIC DESIGN PHASE

1.1.1 The Consultant shall consult with the Owner to ascertain the requirements of the project and shall confirm such requirements to the Owner.

1.1.2 The Consultant shall provide a preliminary evaluation of the program and the project budget requirements, each in terms of the other.

1.1.3 The Consultant shall review with the Owner alternative approaches to design and construction of the project.

1.1.4 Based on the mutually agreed upon program and project budget requirements, the Consultant shall prepare, for approval by the Owner, Schematic Design Documents consisting of drawings and other documents illustrating the scale and relationship of project components.

1.1.5 When required by Owner as identified in Exhibit A, the Consultant shall present Schematic Design Documents at a meeting of the Governing Board of the Owner. The presentation shall include a color perspective of the exterior and brochures consisting of site plans, proposed utility connections, floor plans, elevations and outline specifications of all architectural, structural, electrical and mechanical systems, materials, and such other essentials as may be appropriate.

1.1.6 The Consultant shall submit to the Owner, a Statement of Probable Construction Cost based on current area, volume or other unit costs.

1.2 DESIGN DEVELOPMENT PHASE

1.2.1 Based on the approved Schematic Design Documents and any adjustments authorized by the Owner in the program or project budget, the Consultant shall prepare, for approval by the Owner, Design Development Documents consisting of drawings and other documents to fix and describe the size and character of the entire project as to architectural, structural, mechanical and electrical systems, materials, and such other elements as may be appropriate.

1.2.2 The Consultant shall submit to the Owner, a further Statement of Probable Construction Cost.

1.3 CONSTRUCTION DOCUMENTS PHASE

1.3.1 Based on the approved Design Development Documents and any further adjustments in the scope or quality of the project or in the project budget authorized by the Owner, the Consultant shall prepare, for approval by the Owner, Construction Documents consisting of drawings and specifications setting forth in detail the requirements for the construction of the project.

1.3.2 The Consultant shall assist the Owner in the preparation of the necessary bidding information, bidding forms, the conditions of the contract, and the form of Agreement between the Owner and the Contractor.

1.3.3 The Consultant shall advise the Owner of any adjustments to previous Statements of Probable Construction Cost indicated by changes in requirements or general market conditions.

1.3.4 The Consultant will present the Construction Documents at a meeting of the governing board of Owner, when required by the Owner as identified in Exhibit A.

1.4 BIDDING PHASE

1.4.1 The Consultant, following the Owner's approval of the Construction Documents and of the latest statement of Probable Construction Cost, shall assist the Owner in obtaining bids and in awarding construction contracts.

1.4.2 The Consultant shall review bids and make recommendation as to lowest and best bid(s) in compliance with contract documents.

1.5 CONSTRUCTION PHASE

1.5.1 The construction phase will commence with the award of the construction contracts, and will terminate upon final acceptance of the project by the owner.

1.5.2 The Consultant shall perform the duties set forth in the General Conditions of the specifications for the project, which will be incorporated in the contract for construction.

1.5.3 The Consultant shall advise and consult with the Owner; and all instructions to the Contractor shall be issued through the Owner's Representative. The Consultant shall have authority to act on behalf of the Owner to the extent provided in the General Conditions of the specifications for the project unless otherwise modified in writing.

1.5.4 The Consultant and his representatives shall at all times have access to the site of the project.

1.5.5 The Consultant shall visit the project site as reasonably required, but not less than as stated in Exhibit A, to familiarize himself generally with the progress and quality of the work and to determine in general if the project is proceeding in accordance with the contract documents. The Consultant shall also visit the project site to solve construction related problems as required at no additional cost to the Owner. On the basis of his on-site observations as Consultant, he shall guard the Owner against defects and deficiencies in the work of the Contractor, and shall inform the Contractor and the Owner of those actions required to correct such defects and deficiencies.

1.5.6 Based on such observations at the site and on the Contractor's application for payment, the Consultant shall determine the amount owing to the Contractor and shall approve certificates for payment of such amounts. By approving a certificate of payment, the Consultant shall not be deemed to represent that he has made any examination to ascertain how and for what purpose the Contractor has used the monies paid on account of the certificate of payment.

1.5.7 The Consultant shall not have control or charge of and shall not be responsible for construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the work, for the acts or omissions of the Contractor, Subcontractors or any other persons performing any of the work.

1.5.8 The Consultant shall be the interpreter of the requirements of the Contract Documents. The Consultant shall provide interpretation of the Contract Documents within twenty-four hours of a request for interpretation. The Consultant shall advise the Owner on all claims of the Contractor relating to the execution and progress of the project and on all other matters or questions related thereto.

1.5.9 The Consultant shall have authority to reject work which does not conform to the Contract Documents. The Consultant shall advise the Owner if, in his reasonable opinion, the Contractor is not exercising proper performance of the contract. The Consultant has the authority to require special inspection or testing of any work in accordance with the provisions of the project drawings and specifications, whether or not such work be fabricated, installed or completed.

1.5.10 The Consultant shall review and approve shop drawings, samples and other submissions of the Contractor, only for conformance with the design concept of the project and for compliance with the information given in the project drawings and specifications, and shall return said reviewed items to the Contractor within fourteen (14) consecutive calendar days of receipt thereof.

1.5.11 The Consultant shall assist in preparation of change orders which shall be considered as part of the contract documents, when approved by the Owner. Change Orders which result from design errors by the Consultant shall be prepared by the Consultant at no additional cost to the Owner.

1.5.12 The Consultant shall assist Owner in conducting inspections to determine the dates of substantial completion and final completion. The Consultant shall receive written guarantees and related documents assembled by the contractor, shall approve a final certificate of payment and shall issue certification to the Owner that the project has been completed in general accordance with the project drawings, specifications and applicable codes. The Consultant shall issue to Contractor(s) written notification establishing date(s) of substantial completion.

1.6 ADDITIONAL CONSULTANT RESPONSIBILTIES REQUIRED UNDER THE BASIC RATE

The following services are required to be furnished by Consultant under the Basic Rate, the Consultant's fee being as set forth in the Project Description (Exhibit A).

1.6.1 The Consultant shall prepare documents to include alternate bids requested by the Owner per Paragraph 4.2.

1.6.2 The Consultant shall furnish the Owner a set of as-built photographic (non-deteriorating) mylar reproducible prints of the final project drawings within twenty-one (21) days of receipt of the marked up blueline drawings from the contractor. These drawings shall have sufficient line quality to facilitate microfilming.

1.6.3 The Consultant shall furnish all copies of bidding documents as required to bid and construct the project, as a reimbursable expense.

1.6.4 The Consultant shall be responsible for compliance with all applicable codes, standards and Owner's design guidelines in the preparation of project drawings and specifications, unless otherwise authorized by the Owner. Applicable codes, standards and design guidelines shall include, but not be limited to those listed in the University of Missouri, Consultant Procedures and Design Guidelines.

1.6.5 It is understood that the project designed hereunder shall be efficient, economic and reliable and of proven quality material, must harmonize architecturally with the buildings upon the University campus and those buildings to be under construction concurrently. In order to accomplish such purpose, the Consultant shall cooperate mutually with the Owner and with any other Consultants that might be employed by the Owner.

1.6.6 All Architectural and engineering services performed by the Consultant shall be supervised by a Professional Architect and Professional Engineer respectively, who are currently registered in the State of Missouri. In addition, the firm of the Consultant shall be currently registered by the State of Missouri. All project drawings and specifications shall bear the seal of the Professional Architect and/or Engineer. The Consultant shall certify by signing one drawing that the Consultant has complied with all applicable codes and standards, unless the Owner has granted exceptions in writing.

1.6.7 If the staff of the Consultant does not regularly embrace qualified Architects/Engineers for all phases of the work, the Consultant shall select and employ competent Architects/Engineers, subject to the approval of the Owner. A list of the Consultants shall be furnished in writing to Owner.

1.6.8 The Consultant shall provide Life-Cycle Cost Studies of Alternative Building Systems when required in Exhibit A.

1.6.9 The Consultant shall provide Owner with a certificate of insurance listing the Curators of the University of Missouri, its officers and employees as additional named-insureds and verifying that Consultant is covered by appropriate professional liability insurance in an amount not less than as stated in Exhibit A, which insurance policy shall be endorsed to provide that the same will not be cancelled or altered until after the Owner has received ten days' prior written notice, and which insurance policy be on an occurence basis.

1.6.10 The Consultant shall provide energy consumption information for the project in the form of Btu/sq. ft./year, when required in Exhibit A.

1.6.11 The Consultant agrees to perform its services under this contract in such a manner that will not cause undue delay for the Contractor in the performance of the construction contract.

1.7 ADDITIONAL SERVICES

The following services are not covered in Paragraph 1.1 through 1.6. If any of the following services are requested by the Owner, additional compensation shall be allowed as hereinafter provided.

1.7.1 If Design Development Documents or Construction Documents have been approved by the Owner, and Owner should desire to increase or reduce the scope of the project or require any other changes not necessary to bring the cost of the project within the fixed limit for construction cost allocated by the Owner, and the Consultant shall thereby be caused extra drafting or other expense for which it would not be reasonably compensated by applying the basic rate to the cost of construction, the Consultant shall be entitled to reasonable compensation for such extra drafting and expense provided, however, the Consultant shall not be entitled to extra compensation unless the maximum amount of such compensation shall be agreed upon in writing prior to the time that the Consultant makes such revisions. In case of conflict, the provisions of Paragraph 3.5 shall be controlling.

1.7.2 When additional professional services are made necessary by the default of the Contractors in the performance of their contracts.

ARTICLE 2
THE OWNER'S RESPONSIBILITIES

2.1 The Owner shall provide full information regarding its requirements for the project.

2.2 The Owner shall allocate a fixed limit for construction cost as hereinafter defined, together with an overall project budget.

2.3 The Owner shall designate, when necessary, a representative authorized to act in its behalf with respect to the project. The Owner or his representative shall examine documents submitted by the Consultant and shall render decisions pertaining thereto promptly, to avoid unreasonable delay in the progress of the Consultant's work.

2.4 The Owner shall furnish or direct the Consultant to secure, as a reimbursable expense, a certified land survey of the site, giving, as applicable, grades and lines of streets, alleys, pavements and adjoining property; rights-of-way, restrictions, easements, encroachments, deed restrictions, boundaries and contours of the site; locations, dimensions and complete data pertaining to existing buildings, other improvements and trees; and full information concerning available service and utility lines, both public and private.

2.5 The Owner shall furnish existing certified soils reports including test borings, test pits, soil bearings values, which will assist in determining subsoil conditions. If such reports are not available, the Owner may direct the Consultant to obtain such tests as necessary for determining subsoil conditions; and the cost of such tests shall be a reimbursable expense.

2.6 If the Owner observes or otherwise becomes aware of any fault or defect in the project or non-conformance with the contract documents, he shall give prompt written notice thereof to the Consultant.

2.7 The Owner shall furnish information required of him as expeditiously as necessary for the orderly progress of the work.

2.8 The Owner shall provide on-site field inspection during the construction phase.

2.9 The Owner shall furnish all legal accounting and insurance counseling services as may be necessary at any time for the project, including such auditing services as the Owner may require to verify the Contractor's applications for payment or to ascertain how or for what purposes the Contractor uses the moneys paid by or on behalf of the Owner.

ARTICLE 3
CONSTRUCTION COST

3.1 Construction cost as herein defined shall include the sum total of amounts paid to the General Contractor or other Prime Contractors if the work is divided into appropriate classes. In no event shall the construction cost include professional fees, Owner's supervision, reimbursable expenses, legal expenses, advertising, movable equipment for the project, cost of land, or any other expense for which the Owner is responsible. Construction cost shall be determined as follows with precedence in the order listed:

3.1.1 For completed construction, the total cost of all such work;

3.1.2 For work not constructed, the lowest bona fide bid received from a qualified bidder for any or all of such work; or

3.1.3 For work for which bids are not received, (1) the latest detailed cost estimate, or (2) the Consultant's latest statement of probable construction cost.

3.2 Materials and fixed equipment specified by the Consultant and furnished by the Owner shall be included in the construction cost as the lesser of cost or current market value.

3.3 If the Bidding Phase has not commenced within six months after the Consultant submits the Construction Documents to the Owner, any project budget or fixed limit of construction cost shall be adjusted to reflect any change in the general level of prices in the construction industry between the date of submission of the Construction Documents to the Owner and the date on which proposals are sought.

3.4 The construction cost for the project shall not exceed the cost as defined in the Preliminary Cost Estimate (Exhibit B), attached hereto and incorporated by reference, for the project, unless otherwise authorized by the Owner in writing. The Consultant shall make no provision for a bidding contingency in the construction cost.

3.5 The Consultant may propose alternate bids to adjust the construction cost to the fixed limit, but Owner reserves the right to reject any alternate proposals, materials, built-in equipment, component systems or types of construction at any phase of the work, which would in its opinion reduce the efficiency or durability of the project to an extent which the Owner could not condone.

3.6 If the lowest bona fide bid, or the statement of probable construction cost exceeds the fixed limit of construction cost (including the construction contingency in lieu thereof) established as a condition of this agreement, the Owner shall at its option (1) give written approval of an increase in such fixed limit, (2) authorize rebidding of the project within a reasonable time, or (3) cooperate in revising the project scope and quality as required to reduce the probable cost. In the case of (2) or (3), the Consultant, without additional charge, shall modify the drawings and specifications or perform other professional services as necessary to bring the construction cost within the fixed limit.

ARTICLE 4
ALTERNATES

4.1 Upon approval by the Owner, the Consultant may include altenates in the project. All alternates should be additive alternates.

4.2 When the Owner requires the Consultant to include alternates, the construction cost of the additive alternates shall be used to determine the Consultant's compensation. For alternates that a deduct from the base bid and are accepted by the Owner, the Consultant's fee will be based on the construction base bid. For alternates that are additive to the base bid which are not accepted by the Owner, the Consultant's fee will be paid through the Bidding Phase.

4.3 If the Consultant includes alternates for the purpose of determining cost, or to protect the budget established for the base bid, or for any other reason, no compensation will be allowed the Consultant for alternates not accepted.

ARTICLE 5
PAYMENTS TO THE CONSULTANT

5.1 The Basic Rate herein provided shall cover all of the compensation for all basic services to be rendered hereunder and expenses of whatsoever nature incurred by Consultant or his representatives while in the discharge of any duties connected with the project, except where specific provision is otherwise made in this contract, or unless the Owner authorizes the employment of specialists as a direct cost reimbursable expense of Consultant.

5.2 Payments shall be paid in proportion to the services performed. Payments for Basic Rate will be made monthly and at the completion of each phase. The payments shall not exceed the percentages of the basic rate for the completion of such phase as set forth below:

Schematic Design Phase------------------------15%
Design Development Phase-----------------------20%
Construction Document & Bidding Phase----------45%
Construction Phase-----------------------------20%

Total--100%

5.2.2 Payments for reimbursable expenses or other extra compensation over and above the applied Basic Rate shall be made promptly upon presentation of the Consultant's statement of services rendered.

5.3 If the project is abandoned in whole or in part, except where such abandonment is caused by the cost of the project, when bid, being greater than the fixed limit for construction cost allocated by Owner, the Consultant shall be paid for services performed prior to receipt of written notice from the Owner of such abandonment. Payments shall not, however, be made for any phase of the work which has not been authorized in writing by the Owner.

5.4 Should work which has been abandoned in whole or in part be ultimately resumed, the Owner will be allowed full credit for any amount previously paid if the project is substantially the same and a reasonable credit for any studies previously made which would facilitate the performance of his services in a major re-design of the project.

ARTICLE 6
REIMBURSABLE EXPENSES

6.1 Reimbursable expenses are in addition to the professional fee determined by the Basic Rate. They would include items covered in Paragraphs 2.4 and 2.5 if not furnished by the Owner. The furnishing of all copies of the bidding documents will be a reimbursable expense at Consultant's cost without consultant.overhead and profit.

6.2 If authorized in advance by Owner, the direct expense of special consultants for other than the normal services furnished by the Consultant.

6.3 If authorized in advance by the Owner, models or perspectives for the Owner's use are reimbursable direct expenses, except that the perspective required in the preliminary planning phase is not a reimbursable expense.

6.4 Telephone calls; mileage and/or other travel costs; meals and lodging for out-of-town trips; photocopying costs; and expenses of a similar nature, will not be considered a reimbursable expense under this contract unless such items are specifically authorized by the Owner in writing.

ARTICLE 7
TERMINATION OF AGREEMENT

7.1 The Owner may terminate this agreement at any time and for any cause by a notice in writing to the Consultant, for the convenience of the Owner. Upon receipt of such notice, the Consultant shall, unless the notice directs otherwise, immediately discontinue all services and work and the placing of all orders or the entering into contracts for supplies, assistance, facilities and materials in connection with the performance of this contract and shall proceed to cancel promptly all existing orders and contracts insofar as such orders or contracts are chargeable to this contract.

7.2 If the contract be terminated due to the fault of the Consultant, no further payments on account of the fee will thereafter be made, except for services theretofore authorized and performed which are of value to the Owner. If the contract is terminated due to no fault of the Consultant, the Consultant will be paid promptly any unpaid fees and reimbursables for work actually authorized and performed under the contract.

7.3 The notice required under Paragraph 7.1 may be delivered or served upon the Consultant or mailed to the Consultant's last known address by registered mail, and in case the notice is so mailed, it shall be deemed delivered within forty-eight (48) hours after the same is deposited in the mail.

ARTICLE 8
OWNERSHIP OF DOCUMENTS

8.1 All studies, perspectives and plans and specifications shall become the property of Owner whether the work for which they are made be executed or not. The Consultant shall supply the Owner the complete set of all as-built tracings which shall be prepared on mylar, from which the project was constructed.

ARTICLE 9
DISPUTES AND DISAGREEMENTS

9.1 In order to prevent all disagreements between the parties aforesaid in relation to the performance hereof on the part of said Consultant, it is hereby expressly agreed and understood that in case any difference of opinion shall arise between the parties aforesaid as to the performance of service by the Consultant under this agreement, or any other matter connected with said services, the decision of the Assistant Vice President, Business Services of the University of Missouri, shall be final and binding on all parties hereto.

ARTICLE 10
OWNER'S REPRESENTATIVE

10.1 Any written approval, notice or direction provided for or required of the Owner under this contract may be accepted by the Consultant as given by Owner when and only when given over the signature of the Assistant Vice President, Business Services of the University of Missouri, or some other individual duly authorized by the Governing Board of Owner.

ARTICLE 11
ASSIGNMENT

11.1 It is understood that the services to be rendered by the Consultant hereunder are personal in character and that this contract shall not be assigned by Consultant without the written approval of Owner.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be duly executed as of the day and year first above written.

ATTEST:	THE CURATORS OF THE UNIVERSITY OF MISSOURI
Catherine L. Hunt Secretary	L. Thomas Hussey, Assistant Vice President, Business Services
ATTEST:	
Witness	Title

EXHIBIT A

UNIVERSITY OF MISSOURI
PROJECT DESCRIPTION

DATE:

PROJECT:

PROJECT NO.:

PROJECT COORDINATORS: UMca -
Campus -

DESCRIPTION OF PROJECT:

PROJECT SCHEDULE:

Schematic Design Phase
Design Development Phase
Construction Documents Phase
Advertise
Bid Opening
Construction Start
Construction Complete

CONSULTANT FEE: (Basic Rate)

PROJECT REQUIREMENTS:

Minimum Number of Site Visits Required of Consultant During Construction:
Additional Visits shall be Charged at a Rate not to Exceed $ per visit
Amount of Liability Insurance Required of Consultant: $
Presentation to Board of Curators Required:
(If so, Number of Brochures Required)
Rendering Required:
Life Cycle Cost Studies Required for Alternate Building Systems:
Projected Energy Performance Estimate Required:

EXHIBIT B
PRELIMINARY COST ESTIMATE
ARCHITECT/ENGINEER

DATE:

PROJECT:

PROJECT NO.:

ARCHITECT/ENGINEER:

TOTAL ESTIMATED COST OF ENTIRE PROJECT		$ ________
A/E Fee	$ ________	
A/E Reimbursables	$ ________	
Construction Management Fee	$ ________	
Construction Management Reimbursables	$ ________	
Consultant Fees	$ ________	
Surveys and Tests	$ ________	
Movable Equipment, Furniture, Fixtures	$ ________	
Telephone Installation/Equipment	$ ________	
Landscaping	$ ________	
Moving Allowance	$ ________	
Contingency ___%	$ ________	
Advertising ___ Papers	$ ________	
Construction Project Mgr.-Owner ___%	$ ________	
Administration (Owner) .98%	$ ________	
Reproduction ___%	$ ________	
Microfilming	$ ________	
Subtotal		$ ________
TOTAL AMOUNT AVAILABLE FOR CONSTRUCTION		$ ________

FIGURE 4

UNIVERSITY OF MISSOURI

Office of the Asst. Vice President
Business Services

Facilities Management & Planning
6 Clark Hall
Columbia, Missouri 65211
Telephone (314) 882-2321

(Date)

(Consultant Representative)
(Company Name)
(Street Address)
(City, State Zip Code)

RE: (Project Name)
University of Missouri - (Campus)

Dear Mr. (Name):

Enclosed are two copies of the letter agreement for professional services in connection with the above project. Please sign and return one copy of this agreement.

The following people are assigned to this project:

(Name), UMca Project Coordinator
(Name), Campus Coordinator

Please forward all correspondence to the UMca Project Coordinator and carbon copy the Campus Coordinator. Please do not distribute any other copies of correspondence.

The enclosed University of Missouri Voucher forms should be used when submitting bills for this project.

Sincerely,

(Director's Name)
(Title)

Enc.

cc: (UMca Project Coordinator)
(Campus Coordinator)

UNIVERSITY OF MISSOURI
LETTER AGREEMENT FOR
PROFESSIONAL SERVICES

(Date)

This Agreement is to confirm the University of Missouri and (Name of Consultant) have agreed that consultant is to provide professional services for (short project description). Services shall be in accordance with Exhibit A attached.

Compensation for this work shall be in the amount of $(   ), excluding reimbursables. Payments are to be made on the basis of work completed to date of billing, with final payment following the review and acceptance of documentation described in Exhibit A.

Work under this agreement shall be completed by (completion date).

ACCEPTED:

(Director's Name) (Title)	(Consultant Name)
	Date

Project #(   )

120

FIGURE 5

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University of Missouri

Revised: 11/1/82

GENERAL CONDITIONS

INDEX Page No.

1. Definitions G/1
2. Specifications and Drawings G/2
3. Rights of Architect G/2
4. Inspection and Supervision G/2
5. Compliance with Laws, Permits, Regulations & Inspections G/3
6. Nondiscrimination in Employment G/3
7. Anti-Kickback G/3
8. Duties of Contractor G/3
9. Separate Contracts and Cooperation G/5
10. Subcontractor G/5
11. Assignment of Contract G/5
12. Temporary Facilities G/5
13. Commencement, Prosecution and Completion .. G/5
14. Delay in Completion G/6
15. Progress and Payment Schedule G/6
16. Partial Occupancy G/6
17. Insurance G/6
18. Indemnification G/7
19. Patents G/7
20. Materials and Workmanship G/7
21. "Or Approved Equal" Clause G/8
22. Samples, Tests and Certificates G/8
23. Shop Drawings G/8
24. Changes in Work G/8
25. Rights of Owner on Breach G/9
26. Payments G/9
27. Owner's Right to Withhold Certain Amounts and Make Application Thereof G/10
28. Record Drawings G/10
29. Warranties and Operating Instructions G/10
30. Operating and Service Manuals G/10
31. General Guarantee G/10
32. Required Provisions Deemed Inserted G/11
33. Wage Rates G/11
34. Differing Site Conditions G/11
35. Codes and Standards G/11

General Conditions

These General Conditions must be carefully read by each contractor and subcontractor and are to be considered as applying to each section of the specifications, and all contractors and subcontractors are subject to their provisions.

Their purpose shall be to define the relations of Architect, Owner, Contractors, and all Subcontractors, each to the other, and to establish certain rules and set forth certain provisions governing performance of the work and operations of all of them to the end that the work may be carried on and completed in a safe, expeditious, orderly and workmanlike manner; and the General Conditions, together with the specifications and other contract documents, shall establish the standard of materials and workmanship used so that the project herein referred to shall be a complete and finished piece of work and so that all portions of the same may be executed in the best manner known to each respective trade.

1. DEFINITIONS

As used in these contract documents, the following terms shall have the meanings and refer to the parties designated in these definitions.

a. Owner
The Curators of the University of Missouri. Owner may act through its Board of Curators or any duly authorized committee or representative thereof. Communications to Owner shall be forwarded via Director of Facilities Management, Room 6, Clark Hall, University of Missouri, Columbia, Missouri 65211.

b. Architect
When the term "Architect" is used herein, it shall refer to the Architect or Engineer specified and defined in the Special Conditions or his duly authorized representative. Communications to the Architect shall be forwarded to the address shown in Special Conditions.

c. Owner Representative
Director of Facilities Management or such person as he may authorize to act for him, shall be the authorized representative of the Owner. All communications from the architect to the contractor and from the contractor to the architect shall be through the Owner Representative. Communications to him shall be addressed to Room 6, Clark Hall, 406 Turner Avenue, University of Missouri, Columbia, Missouri 65211.

d. Contractor
Party or parties who have been awarded a contract to furnish work under these specifications and drawings. Any notice to any Contractor from Owner, relative to any part of this contract, shall be in writing and considered delivered and service thereof complete when said notice is posted by registered or certified mail to said Contractor at his last given address or delivered in person to said Contractor or his authorized representative on the work.

e. Subcontractor
A Subcontractor is a person or organization who has a direct contract with the Contractor to perform any of the work at the site. The term "Subcontractor" is referred to throughout the contract documents as if singular in number and masculine in gender and means a subcontractor or his authorized representative. The term "Subcontractor" also is applicable to those furnishing materials to be incorporated in the project whether work performed is at the site or in factory, or both. A sub-contractor is a person or organization who has a direct or indirect contract with a Subcontractor to perform any of the work at the site. Nothing contained in the contract documents shall create any contractual relation between the Owner or the Architect and any subcontractor or sub-contractor.

f. Work
Labor, material, supplies, plant and equipment required to perform and complete the service agreed to by the Contractor in a safe, expeditious, orderly and workmanlike manner so that the project shall be complete and finished in the best manner known to each respective trade.

g. Approved
The terms "approved," "equal to," "directed," "required," "ordered," "designated," "acceptable," "satisfactory," and

similar words or phrases shall be understood to have reference to action on part of the Architect.

h. The contract documents consist of the executed Contract, Performance Bond, Advertisement for Bids, Information for Bidders, Proposal for Lump Sum Contract, Bidder's Statement of Qualifications, General Conditions, Special Conditions, Project Specifications, and any Supplemental Conditions included and Addenda issued prior to the receipt of proposals for the contract and all modifications thereunto, Insurance, Notice to Proceed, and all Drawings pertaining to the project. A modification is (1) a written amendment to the contract signed by both parties, (2) a change order, (3) a written order for a minor change in the work issued by the Architect pursuant to subparagraph (2) below. A modification may be made after execution of the contract.

(1) Written interpretations necessary for the proper execution or progress of the work, in the form of drawings or otherwise, will be issued with reasonably promptness by the Architect through the Owner Representative and in accordance with any schedule agreed upon. Such interpretations shall be consistent with and reasonably inferable from the contract documents.

(2) CHANGES IN THE WORK
The Architect shall recommend to the Owner changes in the work whether or not involving an adjustment in the contract sum or an extension of the contract time and not inconsistent with the intent of the contract documents. Such changes may be affected by change order issued by Owner. Such changes shall be binding on the Owner and the Contractor.

i. Substantial Completion
The date at which all punch list items are completed, and approval by Architect and Owner is given in writing.

2. SPECIFICATIONS AND DRAWINGS

a. Specifications are separated into titled sections for convenience of reference only and to facilitate letting of contracts and subcontracts. Such separations shall not, however, operate to make Architect an arbiter to establish limits of subcontracts or to establish jurisdiction.

b. The drawings, herein referred to, consist of plans prepared by the Architect and are identified and incorporated in these specifications.

c. Drawings are intended to show general arrangements, design and extent of work and are partly diagrammatic. As such, they are not intended to be scaled for roughing-in measurements or to serve as shop drawings.

d. Figured dimensions take precedence over scaled measurements and details over smaller scale general drawings.

e. In case of discrepancy between drawings and specifications, specifications shall govern. Should discrepancies in architectural drawings, structural drawings and mechanical drawings occur, architectural drawings shall govern; and in case of conflict between structural and mechanical drawings, structural drawings shall govern.

f. Should discrepancies in contract documents occur, either in quality or quantity of work required. Contractor shall, unless clarification has been issued by addenda prior to receipt of proposals, furnish and install work in accordance with either of the conflicting provisions of the documents as Architect may direct through the Owner Representative without additional cost to Owner.

g. Anything shown on drawings and not mentioned in these specifications, or vice versa, as well as any work which is obviously necessary to complete the project within the limits established by the drawings and specifications, although not shown on or described therein, shall be performed by the Contractor as a part of his contract.

h. Data concerning lot size, ground elevations, present obstructions on or near the site, locations and depths of sewers, conduits, pipes, wires, etc., position of sidewalks, curbs, pavements, etc., and nature of ground and sub-surface conditions have been obtained from sources the Architect believes reliable, but accuracy of such data is not guaranteed and is furnished solely for the accommodation of the Contractor. Use of such data is made at the Contractor's risk, and no additional allowance will be granted because of Contractor's lack of knowledge of existing site conditions.

i. Only work included in the contract documents is authorized, and the Contractor shall do no work other than that described therein.

j. Drawings consist of sheets enumerated in these specifications, and of such detailed drawings and instructions as shall be provided during the progress of the work, to fully explain and carry out the requirements of these specifications and the drawings.

k. All drawings, specifications and copies thereof furnished by the Owner are and shall remain its property. They are not to be used on any other project and with the exception of one contract set for each party to the Contract, are to be returned to the Owner, on request, at the completion of the work.

3. RIGHTS OF ARCHITECT

a. Architect shall give, through the Owner Representative, all orders and directions contemplated under the contract and specifications relative to the execution of the work. Architect shall determine amount, quality, acceptability and fitness of kinds of work and materials which are to be paid for under this contract and shall decide all questions which may arise in relation to the work. Architect's estimates and decisions shall be final and conclusive, except as herein otherwise expressly provided. In case any question shall arise between the parties hereto relative to the contract or specifications, determination or decision of the Architect shall be a condition precedent to the right of the Contractor to receive any money or payment for work under the contract affected in any manner or to any extent by such question.

b. Architect shall decide the meaning and intent of any portion of the specifications and of any drawings where the same may be found obscure or be in dispute.

c. Architect, through Owner Representative, or Owner Representative may, by written notice request a Contractor to dismiss forthwith any of his or his Subcontractor's superintendents, foremen, workmen, watchmen or other employees whom Architect or Owner Representative may deem incompetent, careless or a hindrance to proper timely execution of the work, and Contractor shall comply with such notice as promptly as practicable without detriment to the work or its progress.

d. If Contractors or Subcontractors refuse to cooperate with the instructions and reasonable requests of other contractors in the overall coordinating of the work, the Architect, through Owner Representative, or Owner Representative may take such appropriate action and issue such instructions as in its judgment may be required to avoid unnecessary and unwarranted delay.

e. If, in the judgment of the Architect, it becomes necessary at any time to accelerate work, any Contractor, when ordered by Architect, through Owner Representative, in writing, shall cease work at any point and transfer his men to such point or points and execute such portions of his work as may be required to enable others to hasten and properly engage and carry out their work, all as directed by the Architect.

4. INSPECTION AND SUPERVISION

a. The Architect, the Owner and any representative of either shall, at all times, have access to the work wherever it is in preparation or progress; and Contractors shall provide proper facilities for such access and for inspection and supervision.

b. During progress of work, the Owner will be represented at the project by an Owner Representative whose duty it will

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be to see that the Contract is properly fulfilled and whose orders and instructions to the Contractor shall have the same power and effect as if given directly by Architect or Owner, as the case may be.

c. The Architect's supervision is for the purpose of assuring the Owner that the drawings and specifications are being properly executed. Although Owner Representative is instructed to confer with Contractor regarding interpretation of plans and specifications and otherwise, such assistance shall not relieve Contractor of any responsibility for the work.

d. The fact that the Architect or Owner has failed to observe faulty work, or work done which is not in accordance with the drawings and specifications, shall not relieve the Contractor from responsibility for correcting such work without additional compensation.

e. If laws, ordinances, any public authority or these specifications require any work to be specifically tested or approved, Contractor shall give Owner Representative timely notice of date fixed for such inspection.

f. The Architect or the Owner's Representative may require project coordination meetings that shall be attended by representatives of the Contractor, appropriate Subcontractors, and suppliers for supplies furnished.

5. COMPLIANCE WITH LAWS, PERMITS, REGULATIONS AND INSPECTIONS

Contractor shall comply with all applicable laws, ordinances, rules and regulations. Construction on Owner's property: Since Owner is an instrumentality of the State of Missouri, municipal or political subdivision ordinances, zoning ordinances, construction codes and other like ordinances are not applicable to construction on Owner's property and Contractor will not be required to submit plans and specifications to any municipal or political subdivision authority, obtain construction permits or any other licenses or permits from or submit to, inspection by any municipality or political subdivision relating to the construction of this project. All permits or licenses required by municipality or political subdivision for operation on property not belonging to Owner, shall be obtained by and paid for by Contractor.

6. NONDISCRIMINATION IN EMPLOYMENT

EQUAL OPPORTUNITY: During the performance of this contract the Contractor agrees as follows:

a. The Contractor will not discriminate against any employee or applicant for employment because of race, religion, color, age, sex or national origin. The Contractor will take affirmative action to insure that applicants are employed and that employees treated during employment without regard to their race, religion, color, age, sex or national origin. Such action shall include, but not be limited to, the following: Employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places available to employees and applicants for employment, notices to be provided by an appropriate agency of the Federal Government setting forth the requirements of these nondiscrimination provisions.

b. The Contractor will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, religion, color, age, sex or national origin.

c. The Contractor will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice to be provided advising that the labor union or workers' representative of the Contractor's commitments under Section 202 of the Executive Order No. 11246 of September 24, 1965, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

d. The Contractor will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of rules, regulations and relevant orders of the Secretary of Labor.

e. The Contractor will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, and by the rules, regulations and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by an appropriate agency of the Federal Government and by the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations and orders.

f. In the event of the Contractor's noncompliance with the Equal Opportunity conditions of this contract or with any such rules, regulations or orders, this contract may be cancelled, terminated or suspended in whole or in part, and the Contractor may be declared ineligible for further government contracts, or federal assisted contracts, in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in said Executive Order, or by rule, regulation or Order of the Secretary of Labor, or as otherwise provided by law.

g. The Contractor will include this subparagraph and the preceding six (6) subparagraphs in every subcontract or purchase order unless exempt by rules, regulations or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, so that such provisions will be binding upon each Subcontractor or vendor. The Contractor will take such action with respect to any Subcontractor or vendor as the appropriate agency of the Federal Government may direct as a means of enforcing such provisions, including sanctions for noncompliance: provided, however, that in the event the Contractor becomes involved in, or is threatened with, litigation with a Subcontractor or vendor as a result of such direction by the appropriate agency of the Federal Government, the Contractor may request the United States to enter into such litigation to protect the interests of the United States.

h. Exemptions to the requirements of the above Equal Opportunity conditions are contracts and subcontracts not exceeding $10,000, and contracts and subcontracts with regard to work performed outside the United States by employees who were not recruited in the United States.

i. The University of Missouri subscribes to the principles of equal opportunity employment. Contractors and Subcontractors should make every effort to recruit and employ minority employees in all trades used in the construction of a project.

7. ANTI-KICKBACK

a. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

b. No official of the Owner who is authorized in such capacity and on behalf of the Owner to negotiate, make, accept or approve, or to take part in negotiating, making, accepting or approving any architectural, engineering, inspection, construction or material supply contract or any subcontract in connection with the construction of the project shall become directly or indirectly interested personally in this contract or in any part thereof, any material supply contract, subcontract, insurance contract, or any other contract pertaining to the project.

c. The Contractor shall comply with the Copeland Regulations of the Secretary of Labor (29 CFR, Part 3) which are incorporated herein by reference. In addition, the Weekly Statement of Compliance required by these Regulations shall also contain a statement that the fringe benefits paid are equal to or greater than those set forth in the minimum wage decision.

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8. DUTIES OF CONTRACTOR

a. Contractor shall supply sufficient labor, material, plant and equipment and pay when due any laborer, Subcontractor, or supplier for supplies furnished and otherwise prosecute the work with diligence to prevent work stoppage and insure completion thereof within the time specified.

b. Contractor, if an individual, shall give the work proper amount of personal supervision, and if a partnership or corporation or joint venture the work shall be given proper amount of personal supervision of partner or executive officer.

c. Contractor and each of his Subcontractors shall submit to Owner such schedules of quantities and costs, progress schedules, payrolls, reports, estimates, records and other data as Owner may request concerning work performed or to be performed under the contract.

d. Contractor shall furnish, from the beginning of the project until its final acceptance, a competent superintendent or foreman who shall establish and maintain a permanent bench mark to which access may be had during progress of the work, who shall give all lines and levels, and who shall be responsible for the correctness of such.

e. Contractor shall be represented at the site, by a competent superintendent or foreman from beginning of work until its final acceptance, unless otherwise permitted by Owner Representative. The superintendent or foreman for the Contractor for the general building work shall exercise general supervision over all Contractors engaged on the work with decision making authority of contractor.

f. No pleas as to act, orders or supervision of Architect, Owner, or any other person shall be admitted in justification of any errors in construction or departure from terms of the contract, except for duly executed change orders or additional supplemental contracts, in writing, signed by Owner.

g. Contractor shall be responsible for laying out his own work and for any damage which may occur to work of any other Contractor because of errors or inaccuracies, as well as be responsible for unloading, uncrating and handling of all materials and equipment to be erected or placed by him, whether furnished by Contractor or others. Layout of work by Subcontractors shall be coordinated with layouts of all general construction work. Unless otherwise directed by Architect, salvage materials, waste and scrap resulting from such work shall be promptly removed from the site by the responsible Contractor.

h. Contractor shall limit operations and storage of material to the area within the project limit lines shown on plot plan, except as necessary to connect to existing utilities, and shall not encroach on neighboring property; and shall exercise caution to prevent damage to existing structures.

i. Contractor shall prearrange time with the Owner Representative in case it becomes necessary for the interruption of any service to make connections, alterations or relocations and shall fully cooperate with Owner in doing work so as to cause the least annoyance and interference with the continuous operation of the University.

j. Contractor shall coordinate all work so there shall be no prolonged interruption of existing equipment. Any existing plumbing, heating, ventilating, air conditioning or electrical disconnections necessary, which affect portions of this construction or building or any other building, must be scheduled with the Owner Representative to avoid any disruption of operation within the building or construction or other building or utilities. In no case shall utilities be left disconnected at the end of a work day or over a weekend. Any interruption of utilities, either intentionally or accidentally, shall not relieve the contractor responsible for the interruption from repairing and restoring the utility to normal service. Repairs and restoration shall be made before the workman responsible for the repair and restoration leave the job.

k. Contractor shall be responsible for repair of his damage to property on or off the project occurring during construction of project, and all such repairs shall be made to meet local code requirements or to satisfaction of Owner if code is not applicable.

l. Contractor shall not overload, or permit others to overload, any part of any structure during building operations.

m. Contractor shall be responsible for shoring required to protect his work or adjacent property owners and shall pay for any damage caused by failure to shore or by improper shoring or by failure to give proper notice. Shoring shall be removed only after completion of permanent supports.

n. During the performance of work, the Contractor shall be responsible for providing and maintaining warning signs, lights, signal devices, barricades, guard rails, fences and other devices appropriately located on site which will give proper and understandable warning to all persons of danger of entry onto land, structure or equipment. Such warning and protective devices shall be removed only when approved by the Architect.

o. Contractor shall be responsible for protection, including weather protection, and proper maintenance of all equipment and materials installed, or to be installed by him.

p. Contractors shall be responsible for care of his finished work and must protect same from damage or defacement until acceptance by the Owner. All damaged or defaced work shall be repaired or replaced to Owner's satisfaction, at expense of Contractor.

q. Contractor shall comply with all applicable ordinances, rules and regulations (see Paragraph 5 of General Conditions). Contractor shall save the Owner and the Architect harmless as a result of any failure to do so.

r. If Contractor observes that drawings and specifications are at variance with any laws, ordinances, rules, regulations or codes applying to work, he shall promptly notify the Architect, thru the Owner Representative, in writing, and any necessary changes shall be adjusted as provided in contract documents.

s. When requested by Owner Representative, Contractor, at no extra charge, shall provide scaffolds or ladders in place as may be required by the Architect or Owner for examination of work in progress or completed.

t. No project signs shall be erected without the approval of the Owner.

u. Contractor shall verify all measurements. No extra charges or compensation will be allowed as a result of the failure to verify dimensions before ordering materials or fabricating items.

v. Contractor shall provide, at the proper time, such material as is required for support of his work. If openings or chases are required, whether shown on drawings or not, he shall see that they are properly constructed. If required openings or chases are omitted, Contractor shall cut them at his own expense, but only as directed by Architect, through Owner Representative.

w. Contractor shall maintain at his own cost and expense, adequate, safe and sufficient walkways, platforms, scaffolds, ladders, hoists and all necessary, proper and adequate equipment, apparatus and appliances useful in carrying on work and to make the place of work safe and free from avoidable danger, and as may be required by safety provisions of applicable laws, ordinances, rules, regulations and building and construction codes.

x. Provisions of "Manual of Safety in Construction" as published by A.G.C. shall be followed by all Contractors and Subcontractors to the extent that such provisions are not in contravention of applicable law.

y. Contractor shall comply with requirements of the Williams-Steiger Occupational Safety and Health Act of 1970.

z. Contractor shall be responsible for removal of all rubbish, debris, and dirt resulting from work and shall clean up as requested by the Architect and Owner Representative. Contractor and Subcontractor shall be responsible for the cost of their respective clean up and removal from premises. The Contractor shall perform this work. The building and premises shall be kept clean, safe, in a workmanlike manner and in compliance with OSHA standards at all times. At completion of work, all dirt, stains and smudges shall be removed from every part of the building, all glass in doors and windows shall be washed, and entire work shall be left broom clean in a finished state ready for occupancy. Contractor shall advise his Subcontractors of this provision, and the Contractor shall be fully responsible for leaving the premises in a finished state ready for use.

aa. Contractor shall maintain one complete set of documents relating to applicable portions of work for use of the Architect and Owner Representative. Authorized changes due to job conditions shall be promptly recorded by Contractor on said set of documents.

bb. Contractor for the general construction work shall establish and be responsible for wall and partition locations on all forms marked with a permanent type of paint. Other Contractors and Subcontractors shall observe these locations and be responsible for setting their sleeves, openings or chases in accordance.

cc. Contractor for construction work shall pump, bail or otherwise keep general excavations free of water. Subcontractors shall keep their individual excavations free of water in an approved manner. Contractor shall keep all areas free of water before, during and after concrete placement.

dd. If any work is required to be specially tested or approved, Contractor shall give the Owner Representative timely notice of date for such inspection.

ee. Contractor shall do all cutting, fitting, or patching of his work, that may be required, to make its several parts come together properly and fit it to receive, or be received by work of other Contractors or Subcontractors shown upon, or reasonably implied by, drawings and specifications for the completed work and he shall make good after them as the Architect may direct.

(1) Any cost caused by defective or ill-timed work shall be borne by party responsible therefor.

(2) Contractor shall not endanger any work by cutting, digging or otherwise and shall not cut or alter work of any other Contractor, save with consent of the Architect.

9. SEPARATE CONTRACTS AND COOPERATION

a. Owner reserves the right to let other contracts in connection with the work.

b. It shall be the duty of each Contractor to whom any one of the above general divisions of work may be awarded, as well as all Subcontractors employed by them, to communicate immediately with each other in order to schedule work, locate storage facilities, etc., in a manner that will permit all Contractors to work in harmony in order that work may be completed in the manner and within the time specified.

c. No Contractor shall delay any other Contractor by neglecting to perform his work at the proper time. Each Contractor shall be required to coordinate his work with other Contractors so as to afford others reasonable opportunity for execution of their work. Any costs caused by defective or ill-timed work, including liquidated damages, if same as prescribed, shall be borne by Contractor responsible therefor.

d. Each Contractor shall be responsible for damage to Owner's or other Contractor's property done by him or men in his employ, through his or their fault or negligence. If any Contractor shall cause damage to any other Contractor, the Contractor causing such damage shall upon notice of any claim, settle with such Contractor by agreement or arbitration.

e. Contractor shall not claim from Owner money damages or extra compensation under this contract when delayed in initiating or completing its performance hereunder, when the delay is caused by labor disputes, natural causes such as fire and wind, but not limited thereto, or the failure of any other Contractor to complete its performance under any contract with the Owner, where any such cause is beyond the Owner's reasonable control.

f. Progress schedule of the Contractor for the General construction work shall be submitted to other Contractors to permit coordinating their progress schedule to the general construction work.

10. SUBCONTRACTOR

a. Subletting of any part of the contract without written approval of the Architect will not be permitted. Any work performed prior to receipt of such written approval will be subject to rejection and removal from site.

b. Contractor shall be responsible to Owner for acts, defaults and omissions of his Subcontractors.

c. Every Subcontractor shall be bound by the applicable terms and provisions of the contract documents, but no contractual relationship shall exist between any Subcontractor and the Owner unless the right of the Contractor to proceed with the work is suspended or the contract is terminated, as herein provided, and the Owner, in writing, elects to assume the subcontract.

d. There will be no payment of any periodic estimate until the list of Subcontractors has been supplied and approved.

11. ASSIGNMENT OF CONTRACT

No assignment by Contractor of any amount or any part of the contract or of the funds to be received thereunder will be recognized unless such assignment has had the written approval of Owner and the surety has been given due notice of such assignment and has furnished written consent thereto. In addition to the usual recitals in assignment contracts, the following language must be set forth: "It is agreed that the funds to be paid to the assignee under this assignment are subject to performance by the Contractor of the contract and to claims or liens for services rendered or materials supplied for the performance of the work called for in said contract in favor of all persons, firms or corporations rendering such services or supplying such materials."

12. TEMPORARY FACILITIES

Contractor shall provide, maintain and erect such temporary facilities as may be required by the Special Conditions.

13. COMMENCEMENT, PROSECUTION AND COMPLETION

a. Before Contractor will be permitted to begin work, there must be in the hands of Owner the following proper instruments as described in contract documents:

(1) Contract

(2) Performance Bond

(3) Certificate or Policies of required insurance.

b. Contractor shall submit to Owner for approval one (1) manually signed copy of each of the following:

(1) List of Subcontractors before the notice to proceed will be issued.

(2) Reproducible progress and payment schedule.

(3) Complete breakdown of Contractor's proposal.

(4) List of material suppliers.

Before any payment will be made.

c. Contractor shall commence work upon the date "Notice to Proceed" is received from Owner. He shall prosecute the work with faithfulness and energy, and the entire work shall

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be completed within the number of consecutive calendar days from the date specified in the Proposal Form and Special Conditions.

d. All time limits stated in the contract are of the essence of the contract. However, if the Contractor be delayed at any time in the progress of the work by any act or neglect of the Owner, or the representative of the Owner or by changes ordered in the work, or by strikes, lockouts, fire or any other causes, not limited to the kinds mentioned, beyond the Contractor's reasonable control, or by delay authorized by the Owner, then the time of completion may be extended for a reasonable time and to such date as certified by the Architect; providing further that the Contractor shall within seven (7) days from beginning of any such delay, notify Architect and Owner, in writing, of the cause of the delay, and Architect shall ascertain the facts and extent of the delay and notify the Contractor within a reasonable time of his decision in the matter.

e. When conditions at the site of the proposed work are considered by Owner to be unsatisfactory for prosecution of work, Contractor may be ordered, in writing, to suspend the work or any part thereof until reasonable conditions exist. When such suspension is not due, in the opinion of the Owner, to fault or negligence of the Contractor, time allowed for completion of such suspended work will be extended by a period of time equal to that lost due to delay occasioned by ordered suspension.

f. The Contractor shall execute a Performance Bond as prepared by Owner in an amount equal to one hundred percent (100%) of the contract sum as security for the faithful performance of this contract and as security for the payment of all persons performing labor on the project under this contract and furnishing materials in connection with this contract. The Performance Bond shall be delivered to the Owner not later than the date of execution of the contract.

14. DELAY IN COMPLETION

a. Time is expressly declared to be of the essence in completion of the work covered by these specifications, and the Contractor shall be liable for actual damages for delay in completion of work, but liquidated damages as such for delay in completion of work are not prescribed unless specifically identified in the Special Conditions. Where, under the contract, additional time is allowed for the completion of the work, the new time limit shall be of the essence of the contract.

b. No time extensions will be awarded to the contractor for weather conditions

15. PROGRESS AND PAYMENT SCHEDULE

a. Contractor shall submit for Owner's approval, through Owner Representative in reproducible form one manually signed progress schedule showing rate of progress he agrees to maintain and order in which he proposes to carry on various phases of work. Schedule shall show percentage of work completed at any time, anticipated monthly payments by Owner, as well as significant dates (such as completion of excavation, concrete, foundation work, underground lines, superstructure, roughing-in, enclosure, hanging of fixtures, etc.) which shall serve as check points to determine compliance with approved schedule.

b. An updated progress schedule shall be submitted with each partial payment request. Updated schedule shall indicate work completed to date and work yet to be completed. No partial payment to the contractor will be approved until the receipt of the updated progress schedule.

c. Values employed in preparation of any schedules will be used only for determining basis for partial payments and will not be considered as fixing basis for additions to or deductions from the contract price.

d. There will be no payment of any periodic estimate until the list of Material Suppliers; Progress and Payment Schedule; and Breakdown of Contractor's proposal have been approved.

e. Contractor shall employ and supply a sufficient force of workmen, material, plant and equipment and pay when due, any workmen, Subcontractor or Supplier for supplies furnished and otherwise prosecute the work with diligence to maintain the rate of progress indicated on the progress schedule, prevent work stoppage and insure completion of the project within the time specified. Should Contractor fail in any respect, the Architect or Owner Representative may require that additional workmen, plant and equipment be placed on the work or require that hours in addition to regular hours be worked until progress is as scheduled, with no additional cost to Owner.

f. Should Contractor fail in the performance of his contract; refuse or fail to supply sufficient labor, materials, plant or equipment; to complete work within scheduled time or to prosecute work with such diligence as will insure its completion within the time set forth or any extension thereof, the Owner may, after five (5) days following mailing or personal service of written notice to Contractor's last known address, terminate Contractor's right to proceed with the work or such part thereof as may then be uncompleted.

g. After such action, Owner may proceed to complete the work, either by contract or through use of Contractor's plant and equipment, as well as all materials and appliances intended for work, and may employ persons to complete the work and provide materials therefor. In such event Contractor shall not be entitled to receive any further payments under this contract until the work be wholly finished. Then, if any unpaid balance under the contract shall exceed all expenses of Owner, as certified by Architect, such excess shall be paid to Contractor. However, if such expenses shall exceed the unpaid balance as certified by Architect, Contractor and his surety shall be liable for and pay the differences to the Owner.

h. Nothing in this paragraph shall be construed to limit or in any way affect power and right of Owner to terminate the contract as otherwise herein provided, nor shall it limit the responsibility of Contractor or his surety

16. PARTIAL OCCUPANCY

a. Contractor agrees that Owner, upon advance notification to Contractor, in writing, will be permitted to occupy and use any completed or partially completed portions of the project notwithstanding time for completion of the entire work. Should the owner elect to take partial occupancy for an individual piece of equipment, system, or area, the warranty period shall begin as addressed under term Substantial Competition.

b. If such prior occupancy increases the cost of the work or delays its completion, provided that the same occur prior to the completion date fixed by the "Notice to Proceed," the Contractor shall be entitled to extra compensation or extension of time, or both. However, such claims shall be made in writing prior to such partial occupancy and must be substantiated with supporting data satisfactory to the Owner or Owner Representative, and no such claim shall be honored in the event the time for completion has expired prior to such partial occupancy.

17. INSURANCE

a. Contractor shall provide and maintain, during the life of the contract and until final acceptance of the work, insurance acceptable to the Owner which will afford protection and coverage in accordance with the requirements set forth below.

(1) Workmen's Compensation Insurance Coverage A. Workmen's Compensation Insurance for all of his employees

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at the site of the project, and, in case any work is sublet, Contractor shall require any subcontractor similarly to provide Workmen's Compensation Insurance for all of the latter's employees, unless such employees are covered by the protection afforded by Contractor. This coverage shall comply in all respects with the requirements of the Statutes of the State of Missouri, Coverage B: Employer's Liability, in a limit no less than $100,000.

(2) Public Liability and Property Damage Insurance: Public Liability and Property Damage Insurance in comprehensive general liability form as shall protect Contractor and any subcontractor performing work covered by this contract from claims for damages for personal injury, including wrongful death, and from claims for property damage which may arise from the operations under the contract, including all trucks and automobiles used, whether owned or not, and whether such operations be by the Contractor or any Subcontractor or by anyone directly or indirectly employed by either of them. The amount of insurance shall not be less than the following:

(a) Public Liability Insurance, in limits of not less than $300,000 for injury to, or death of, any one person, and subject to the same limit for each person, not less than $500,000 for injury or death of more than one person arising out of any one accident.

(b) Property Damage Insurance, in limits of not less than $500,000, provided, however, that insurance on all automobiles and trucks shall be for bodily injury in the prescribed limits and property damage limits thereon may be in limits of not less than $100,000. Such policy or policies shall by proper endorsement cover any liability of Contractor under Indemnification, Paragraph 18 of these General Conditions.

(3) Insurance Covering Special Hazards: The Public Liability and Property Damage Insurance policy or Policies of the Contractor shall provide coverage for special hazards such as operation of material hoist, blasting or other use of explosives, and damage to underground property.

(4) Owner's Protective Liability Insurance ORIGINAL POLICY or a certificate of the Original Policy evidencing Protective Liability Insurance for protection of coverage of The Curators of the University of Missouri and the Architect, protecting them against the standard hazards, except liability from operation of trucks and automobiles, and in the same amount of insurance required in the Public Liability and Property Damage Insurance of Contractor. If a certificate of the Original Policy is provided, the owner reserves the right to later request a copy of the Original Policy.

(5) Builder's Risk Insurance: ORIGINAL POLICY or a certificate of the Original Policy evidencing insurance upon the work and all materials, equipment, supplies, temporary structures and similar items which may be incident to the performance of the work and located at or adjacent to the site, against loss or damage from fire and such other casualties as are included in extended coverage in broad comprehensive form, vandalism and malicious mischief, in an amount not less than the replacement cost of the work or the contract price, whichever is greater, with loss payable to Contractor and Owner as their respective interest may appear. If a certificate of the Original Policy is provided, the Owner reserves the right to later request a copy of the Original Policy. Such insurance may be written with Building and Contents Form of Endorsement. In the event Building and Contents Form of Endorsement contains an alterations and repairs permit, Contractor shall maintain sufficient insurance to cover the full value of the work and materials as the work progresses and shall furnish Owner copies of all endorsements. If Builder's Risk Reporting Form of Endorsement is used, Contractor shall make all reports as required therein so as to keep in force an amount of insurance which will be equal to the replacement cost of the work, materials, equipment, supplies, temporary structures, and other property covered thereby; and if, as a result of Contractor's failure to make any such report, the amount of insurance so recoverable shall be less than such replacement cost, Contractor's interest in the proceeds of such insurance, if any, shall be subordinated to Owner's interest to the end that Owner may receive full reimbursement for its loss.

b. All insurance shall be procured through agencies and be written by insurance companies which are acceptable to and approved by Owner and shall be obtained and paid for by Contractor.

c. Contractor shall furnish Owner with certificates, policies or binders which indicate that the Contractor and/or Owner and Architect (where required) are covered by the required insurance prior to the Owner issuing a Notice to Proceed, showing type, amount, class of operations covered, effective dates and dates of expiration of policies. All certificates, policies or binders shall contain the statement: "The insurance covered by this certificate will not be cancelled or altered except after ten days' written notice has been received by the Curators of the University of Missouri."

d. Upon receipt of any notice of cancellation or alterations, Contractor shall, within five (5) days, procure other policies of insurance similar in all respects to the policy or policies about to be cancelled or altered; and if Contractor fails to provide, procure and deliver acceptable policies of insurance or satisfactory certificates or other evidence thereof, Owner may obtain such insurance at the cost and expense of Contractor without notice to Contractor.

e. It is understood and agreed that the insurance required by the provisions of this article is required in the public interest and that Owner does not assume any liability for acts of Contractor, any Subcontractor or their employees in the performance of the contract.

18. INDEMNIFICATION

a. Contractor agrees to indemnify and save harmless, Owner and Architect, their agents, servants and employees, from and against any and all liability for damage arising from injuries to persons or damage to property occasioned by any acts or omissions of Contractor, any Subcontractor, agents, servants or employees, including any and all expense, legal or otherwise, which may be incurred by Owner or Architect, its agents, servants or employees, in defense of any claim, action or suit irrespective of any claims that an act, omission or negligence of Owner or Architect, its agents, servants or employees contributed to such injury or damage.

b. The obligations of the Contractor under this paragraph shall not extend to the liability of the Architect, his agents or employees, arising out of (1) the preparation of approval of maps, drawings, opinions, reports, surveys, change orders, design or specifications or (2) giving of or the failure to give directions or instructions by the Architect, his agents or employees as required by the contract documents provided such giving or failure to give is the primary cause of the injury or damage.

19. PATENTS

a. The Contractor shall hold and save the Owner and its officers, agents, servants and employees harmless from liability of any nature or kind, including cost and expense, for, or on account of, any patented or unpatented invention, process, article or appliance manufactured or used in the performance of the contract, including its use by the Owner, unless otherwise specifically stipulated in the contract documents.

b. If the Contractor uses any design, device, or material covered by letters, patent, or copyright, he shall provide for such use by suitable agreement with the Owner of such patented or copyrighted design, device, or material. It is mutually

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agreed and understood, without exception, that the contract prices shall include all royalties or costs arising from the use of such design, device, or material in any way involved in the work. The Contractor and/or his sureties shall indemnify and save harmless the Owner of the project from any and all claims for infringement by reason of the use of such patented or copyrighted design, device or material or any trademark or copyright in connection with work agreed to be performed under this contract and shall indemnify the Owner for any cost, expense or damage it may be obliged to pay by reason of such infringement at any time during the prosecution of the work or after completion of the work.

20. MATERIALS AND WORKMANSHIP

a. Materials and fixtures shall be new and of latest design, to provide most efficient owning and operating cost, as approved by Architect. All work shall be performed by competent workmen and shall be of best quality.

b. Contractor shall carefully examine the plans and specifications and shall be responsible for the proper fitting of his material, equipment and apparatus into the building.

c. Contractor shall base his proposal only on materials, method of construction and equipment as indicated. Contractor may make a written proposal to Architect to use alternate materials or fixtures, but Architect's decision shall be final.

d. Should specifications fail to particularly describe materials or goods to be used, it shall be the duty of the Contractor to inquire of Architect, through the Owner Representative, what is to be used and to supply it at Contractor's expense or else thereafter replace it to Architect's satisfaction.

e. Materials and workmanship shall be subject to inspection, examination and test by Owner, Architect and their representative at any and all times during manufacture, installation and construction or any of them, at places where such manufacture, installation or construction is carried on. Architect, Owner and their representatives shall have the power and right to reject defective materials and workmanship or to require correction.

f. Contractor shall promptly remove, at his own expense, all rejected materials from site work.

g. When a material has been approved, no change in brand or make will be permitted unless:

(1) Manufacturer cannot make satisfactory delivery, or

(2) Material delivered fails to comply with contract requirements.

h. Unless otherwise specifically noted, the Contractor shall provide and pay for all labor, materials, equipment, tools, construction equipment and machinery, water, heat, utilities, transportation, and other facilities and services necessary for the proper execution and completion of the work.

21. "OR APPROVED EQUAL" CLAUSE

Whenever in any of the contract documents any article, appliance, device or material is designated by the name of the manufacturer or vendor or by any proprietary or trade name such name is followed by the words "or approved equal," "or as approved" or preceded by the words "similar and equal to," the standard products of manufacturers other than those specified will be accepted when, prior to the ordering or use thereof, it is proven to the satisfaction of the Architect that they are equal in design, strength, durability, usefulness and convenience for the purpose intended. Any changes required in the details and dimensions indicated in the drawings for the substitution of standard products other than those called for shall be properly made as approved by Architect at the expense of the Contractor requesting the substitution or change. *Note:* No substitutions will be permitted for components of extensions to existing systems when, in the opinion of the Architect, the named manufacturer must be provided in order to insure compatability with the existing systems, such as fire alarms, smoke detectors, etc. No substitutions will be granted by the Architect prior to receipt of bids.

22. SAMPLES, TESTS AND CERTIFICATES

a. Contractor shall submit samples, at his cost, at least twenty (20) days before materials represented by samples are required to be ordered for scheduled delivery to site.

b. Materials delivered prior to receipt of Architect's approval are subject to rejection and immediate removal from site.

c. Samples shall be labeled to designate material or product represented, grade, place of origin, name of producer and name of Contractor.

d. Approval of material is general and shall not constitute waiver of Owner's right to demand full compliance with contract requirements.

e. Unless Architect is authorized at the time of submittal to return samples at Contractor's expense, rejected samples will be destroyed.

f. After delivery of material, Architect may make such tests as he deems necessary, with samples required for such tests being furnished and at the cost of the Contractor. If the material, equipment or accessory fails to meet the contract requirements, all costs of testing shall be paid by the Contractor. If the item meets with contract requirements, costs of testing will be paid by Owner.

g. Quantities of samples submitted for tests shall be twice that required in order to provide duplicate samples to be retained by Architect.

h. On the basis of the test results, materials, equipment or accessories may be rejected even though general approval has been given. If items have been incorporated in work, Architect shall have the right to cause their removal and replacement by items meeting contract requirements or to demand and secure such reparation to the Owner from the Contractor as is equitable.

i. Architect reserves the right to require Contractor to furnish a certificate guaranteeing that material or equipment as submitted complies with contract requirements. Certificates shall be in notarized affidavit form. If statement originates with manufacturer, Contractor shall endorse all claims and submit statement in his own name.

j. When directed by the Architect, samples of finished masonry and field applied paints and finishes shall be located as directed and shall include sample panels constructed at site of approximately twenty (20) square feet each.

23. SHOP DRAWINGS

a. Shop drawings shall be submitted by the Contractor to the Architect in the form of transparencies except where pertinent information is available in sufficient quantity of acceptable printed matter or catalog cuts. Contractor's selection is to be marked clearly. Transparencies to be of sufficient quality to permit legible microfilming.

b. Shop drawings shall be submitted in a quantity as listed in the Special Conditions.

c. Approval of drawings will not constitute a complete check by Architect (see paragraph 23 "d" below) but will indicate only that general method of construction and detailing is satisfactory.

d. Architect's approval will not relieve the Contractor of responsibility for errors since Contractor is solely responsible for dimensions and design of adequate connections, details and satisfactory construction of all work, as well as furnishing materials and workmanship required by drawings and specifications which may not be indicated on shop drawings when approved.

e. Drawings called for under various headings shall conform to the intent of Architect's drawings and specifications and shall be checked by Contractor for measurements, sizes, materials, details, actual conditions at building and correlation with other work. Errors or omissions shall be corrected prior to submittal to Architect.

f. Contractor submitting late, inadequate or incorrect shop drawings shall be responsible for damage and delays should drawings be rejected by Architect.

g. Contractor shall submit no drawings to Architect without notation on each copy indicating date of approval and signature of checker for Contractor, together with Contractor's name and project identification.

h. Contractor shall schedule submittal of shop drawings to Architect so that no delays will result in delivery of materials and equipment, advising Architect of priority for checking of drawings, but a minimum of two weeks shall be provided for this purpose.

i. All shop drawings must be submitted prior to the receipt of the third partial payment request. After the second payment has been made, no further payments will be made until all shop drawings have been submitted.

24. CHANGES IN WORK

a. Owner, as authorized by its governing body, by written order may authorize changes in or additions to work to be performed or materials to be furnished pursuant to the provisions of the contract.

b. The amount of any adjustment in the contract price for authorized changes shall be agreed before such change becomes effective and shall be determined as follows:

(1) By an acceptable unit price or lump sum proposal from Contractor. Contractor proposal shall include a breakdown of all material, labor, overhead and profit.

(2) By a cost-plus-fixed-fee (percentage) basis with maximum price, total cost not to exceed maximum specified.

(3) By unit prices contained in Contractor's original proposal and incorporated in construction contract.

c. Overhead and profit on Change Orders shall be applied as follows:

1. The overhead and profit charged by the contractor shall be considered to include, but not be limited to: job-site office expense, incidental job burdens, small hand tools, project supervision and general office overhead. The percentages for overhead and profit charged on Change Orders shall be negotiated and may vary according to the nature, extent and complexity of the work involved, but in no case shall exceed the following:

	OVERHEAD	PROFIT
To Contractor on work performed by other than his forces	5%	5%
To first tier subcontractor on work performed by his subcontractor	5%	5%
To Contractor and/or subcontractor for that portion of the work performed with their respective forces or materials purchased	10%	10%

Not more than four mark-ups, not to exceed the maximum shown above, will be allowed regardless of the number of tier subcontractors.

2. On proposals covering both increases and decreases in the amount of the contract, the application of overhead and profit shall be on the net change in direct cost for the Contractor or subcontractor performing the work.

3. The percentages for overhead and profit credit to the Owner on Change Orders that are strictly decreases in the quantity of work or materials shall be negotiated, and may vary according to the nature, extent and complexity of the work involved, but in no case shall it be less than the following:

	OVERHEAD	PROFIT
Credit to the Owner from Contractor on work performed by other than his forces	3%	2%
Credit to the Owner from Subcontractor on work performed by his Subcontractor	3%	2%
Credit to the Owner from Contractor and/or Subcontractor for the portion of the work performed with their respective forces or materials purchased	5%	5%

d. No claim for an addition to the contract sum shall be valid unless authorized as aforesaid in writing by Owner. In the event that none of the foregoing methods are agreed upon, Owner may perform work by force accounts or accounts. The cost of such work shall be determined by the contractors actual labor and material cost to perform the work plus applicable overhead and profit as outlined in paragraph C above. The Owner Representative shall approve daily the contractors time and material for the work.

e. No changes or additions to work to be performed, materials to be furnished, or in the provisions of the contract shall be authorized until execution and delivery by Owner to Contractor of the written order referred to in this paragraph.

25. RIGHTS OF OWNER ON BREACH

a. In the event any provision of the contract is violated, the Owner may serve notice on the Contractor and his surety setting forth the violations and demanding compliance with the contract. Unless within ten (10) consecutive calendar days after serving such notice, such violation shall cease and satisfactory arrangements for correction be made, the Owner may suspend the Contractor's right to proceed with the work or terminate the contract.

b. In the event the Owner suspends Contractor's right to proceed with the work or terminates the contract, the Owner may demand that the Contractor's surety take over and complete the work on the contract; and upon its failure or refusal to do so within ten (10) consecutive calendar days after demand therefor, the Owner may take over the work and prosecute the same to completion for the Contractor by bid or negotiated contract satisfactory to the Owner, or by any other means the Owner may elect and may take possession of and utilize in completing the work such materials, supplies, appliances and plant as may be on the site of the work, and all Subcontractors, if the Owner elects, shall be bound to perform their contracts.

c. The Contractor and his surety shall be and remain liable to the Owner for any excess cost or damages occasioned to the Owner as the result of the actions set forth above.

d. The Contractor, in the event of such suspension or termination shall not be entitled to receive any further payments under the contract until the work is wholly finished. Then if the unpaid balance under the contract shall exceed all expenses of the Owner, as certified by the Architect, such excess shall be paid to the Contractor; but, if such expenses shall exceed the unpaid balance, as certified by the Architect, the Contractor and his surety shall be liable for and shall pay the difference and any damages to the Owner.

e. In exercising Owner's right to secure completion of the work under any of the provisions hereof, Owner shall have the right to exercise Owner's sole discretion as to the manner, methods and reasonableness of costs of completing the work.

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f. The rights of the Owner to suspend or terminate as herein provided shall be cumulative and not exclusive and shall be in addition to any other remedy provided by law.

26. PAYMENTS

a. Payments will be made to Contractor monthly from lawful funds available therefor on the basis of a duly certified estimate of all labor and materials done or delivered on the site of the construction and accepted by the Owner Representative during the preceding month, calculated in proportion to the contract price.

b. Contractor shall render one (1) Executed Periodic Estimate for Partial Payment to Owner by mailing or delivering same to the Office of Facilities Management, Room 6, Clark Hall. All statements shall be subject to approval of the Owner Representative and Architect, after which Owner will prepare its standard payment voucher and submit same to the University's Accounting Department for payment.

c. After approval of the Monthly Periodic Estimate, the Contractor will be reimbursed for ninety percent (90%) of the value of all labor furnished and materials installed and computed in the same manner, less all previous payments made until the Contractor has completed work equal to fifty percent (50%) of the adjusted contract. Thereafter the Contractor will be reimbursed for ninety-five percent (95%) of the value of all labor furnished and material installed and computed in the same manner, less all previous payments made, subject to approval by the Architect and the Owner, and with the consent of the Surety. The Owner may revoke its decision and raise the retention to ten percent (10%) if the Owner concludes that the contractor is behind schedule or that satisfactory progress is not being maintained or that contractor has not made proper payments to subcontractors and material men and suppliers. In no event shall an amount exceeding ninety-five percent (95%) of the entire contract price be paid to the contractor until the contract is satisfactorily completed, the work accepted and the contractor has fulfilled all requirements and provided all the information required for final payment.

d. Each payment made to Contractor shall be on account of the total amount payable to Contractor by or for Owner, and all material and work covered by partial payment made shall thereupon become the sole property of Owner. No such payment shall be deemed to be in accord and satisfaction as to any item or items for which such payment is made and this provision shall not be construed as relieving Contractor from sole responsibility for care and protection of materials and work upon which payments have been made or restoration of any damaged work or as a waiver of the right of Owner to require fulfillment of all terms of the contract.

e. Ordinarily no allowance will be made in estimates for materials delivered on site of work and not incorporated in work; however, items considered by Architect to be major items of considerable magnitude, if suitably stored in a bonded warehouse or on the site, will be allowed in estimates on the basis of ninety percent (90%) of invoices, the value calculated in proportion to contract price. Materials list must be itemized and notarized in the same number of copies as the estimate.

f. Retained percentages herein provided are to be retained and held for the sole protection and benefit of Owner, and no other person, firm or corporation shall have or assert any lien, claim or right whatsoever thereto, except as herein expressly provided.

g. Owner may require at any time before final payment is made that Contractor furnish Owner with written acknowledgements by all Subcontractors and material men who have done work or labor on, or who have furnished materials for, this project that they have been fully paid by Contractor for all such work or labor done or materials furnished by them.

h. Upon approval of the final estimate by the Architect, the Contractor will be requested by Owner to furnish one (1) original notarized certification of the following:

(1) All labor and material costs have been paid.

(2) All Subcontractors and manufacturers furnishing materials and labor for the project have fully completed their work and have been paid in accordance with their contract.

(3) The project has been fully completed in accordance with plans and specifications as modified by Change Orders.

(4) Guarantees as provided by the specifications including General Guarantee for the entire project for one year from the date of substantial completion (Paragraph 31 of the General Conditions) and each specific guarantee requirement of the specifications over and above the one year period.

(5) All payrolls have been submitted, where required by the specifications.

i. The acceptance by the Contractor of final payment shall be and shall operate as a release to the Owner of all claims and all liability to the Contractor for all things done or furnished in connection with this work and for every act and neglect of the Owner and others relating to or arising out of this work. No payment, final or otherwise, shall operate to release the Contractor or his sureties from any obligations under his contract or bond.

j. No recourse shall be had against any member of the Board of Curators or officer thereof for any payment under the contract or any claim based thereon.

k. Where the specifications provide for the performance by the Contractor of certain tests for the purpose of balancing and checking the air conditioning and heating equipment and Contractor shall have furnished and installed all such equipment in accordance with the specifications, but said tests cannot then be made because of weather conditions, such tests may be considered as required under the provisions of the specifications. Paragraph 31 of the General Conditions and the contract may be certified as satisfactorily completed and the work accepted and full payment made, even though the tests have not been made.

27. OWNER'S RIGHT TO WITHHOLD CERTAIN AMOUNTS AND MAKE APPLICATION THEREOF

a. In addition to retained percentage, Owner may withhold such amounts as may be necessary to cover:

(1) Defective work not remedied.

(2) Completion of the contract where there is reasonable doubt that the contract can be completed for the balance then unpaid or within the time specified.

b. If Contractor fails to furnish satisfactory evidence of payment to others as covered in Paragraph 26, then Owner may, after having served written notice on Contractor, either pay unpaid bills of which the owner has written notice, direct, or withhold from Contractor's unpaid compensation a sum of money deemed reasonably sufficient to pay any and all such lawful claims until satisfactory evidence is furnished that all liabilities have been fully discharged, whereupon payment to Contractor shall be resumed in accordance with the terms of the contract, but in no event shall the provisions of this sentence be construed to impose any obligations upon the Owner to either the Contractor or his surety. Any payment so made by Owner shall be considered as a payment under contract by Owner to Contractor, and Owner shall not be liable to Contractor for any such payment made in good faith.

28. RECORD DRAWINGS

Contractor shall at the completion of the work, prepare, receive approval from Owner representative then turn over to the

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Architect, "As Built" drawings. Drawings shall indicate all deviations in the work and shall show all buried inside and outside installations accurately showing all details of the work under their contract. Work shall be dimensioned from permanent structures such as interior or exterior wall faces and finished floors.

29. WARRANTIES AND OPERATING INSTRUCTIONS

Warranties and operating instructions of various equipment items, according to the manufacturer's policy covering their products, shall be delivered in four (4) copies to the Owner Representative at Room 6, Clark Hall, 406 Turner Avenue, University of Missouri, Columbia, Missouri 65211.

30. OPERATING AND SERVICE MANUALS

a. General - At the completion of the project, and at least two (2) weeks prior to Contractor's request for final inspection, each Contractor shall be required to provide four (4) volumes of operating and service manuals to the Owner, containing the following:

(1) Start-up and Shut-down Procedures: Provide a step-by-step write up of all major equipment. When manufacturer's printed start-up, trouble shooting and shut-down procedures are available they may be incorporated into the operating manual for reference.

(2) Operating Instructions: Written operating instructions shall be included for the efficient and safe operation of all equipment.

(3) Equipment List: List of all major equipment as installed shall include model number, capacities, flow rate and nameplate data.

(4) Service Instructions: Each Contractor shall be required to provide the following information for all pieces of equipment.

(a) Recommended spare parts including catalog number and name of local suppliers or factory representatives.

(b) Belt sizes, types and lengths.

(5) Manufacturer's Certificate of Warranty: Manufacturer's certificates of warranty shall be obtained for all major equipment. Warranty shall be obtained for at least one year as defined in the General Guarantee paragraph. Where longer period is called for in the specific equipment specifications, the longer period shall govern.

(6) The Contractor shall furnish the Owner four (4) copies of parts catalogs for each piece of equipment furnished by him on the project with the components identified by number for replacement ordering. Such parts list shall be furnished prior to final payment under the contract.

b. Submission

(1) Manuals shall be in quadruplicate, and all materials shall be bound into volumes of standard 8½" x 11" hard binders. Large drawings too bulky to be folded into 8½" x 11" shall be separately bound or folded into brown envelopes, cross referenced and indexed with the manuals.

(2) The manuals shall identify project and include the name and address of Contractor and major Subcontractors.

31. GENERAL GUARANTEE

a. Neither the final payment nor any provision in the contract documents nor partial or entire occupancy of the premises by the Owner shall constitute an acceptance of work not done in accordance with the contract documents or relieve the Contractor of liability in respect to any express warranties or responsibility for faulty materials or workmanship. The Contractor shall remedy any defects in the work and pay for any damage to other work resulting therefrom which shall appear within a period of one year from the date of substantial completion for the work, unless a longer period is specified. The warranty period shall begin for all items accepted for use under partial occupancy or when projects are approved as addressed under term Substantial Completion. The Owner will give notice of observed defects with reasonable promptness.

b. Should one or more defects mentioned above appear within the specified period, Owner shall have the right to continue to use or operate the defective part of apparatus until Contractor makes repairs or replacements or until such time as it can be taken out of service without loss or inconvenience to Owner.

c. If final payment is made under the provisions of the General Conditions, paragraph 26 (k), any tests required under the specifications for the purpose of balancing and checking air conditioning or heating equipment which have not been made shall be made promptly when weather conditions permit.

32. REQUIRED PROVISIONS DEEMED INSERTED

Each and every provision of law and clause required by law to be inserted in this contract shall be deemed to be inserted herein, and the contract shall be read and enforced as though it were included herein; and if through mistake or otherwise any such provision is not inserted, or is not correctly inserted, then upon the application of either party the contract shall forthwith be physically amended to make such insertion or correction.

33. WAGE RATES

a. Contractor will pay wage rates and fringe payments of not less than the prevailing wage rates and fringe payments for workmen performing work of a similar character in the community where construction under this contract takes place, all as determined by Assistant Vice President Business Services. Prevailing wage rates for the community are on file in the office of the Director of Physical Plant, UMR, UMSL, and UMKC and in the office of Campus Facilities, UMC, and the office of the Business Office of each campus of Owner, and Contractor is responsible for complying therewith.

b. Owner may, at any time, request and inspect Contractor's payrolls for the project to verify compliance.

c. The acquisition of products or services is subject to the supplier's conformance to the rules and regulations of the President's Committee on Equal Employment Opportunity (41 CFR, Ch.60).

34. DIFFERING SITE CONDITIONS

a. The Contractor shall promptly, and before such conditions are disturbed, notify the Architect in writing of:

(1) Subsurface of latent physical conditions at the site differing materially from those indicated in this contract, or

(2) unknown physical conditions at the site, of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inhering in work of the character provided for in this contract. The Architect shall promptly investigate the conditions, and if it is found that such conditions do materially so differ and cause an increase or decrease in the Contractor's cost of, or the time required for, performance of any part of the work under this contract, whether or not changed as a result of such conditions, an equitable adjustment shall be made and the contract modified by change order.

b. No claim of the Contractor under this article shall be allowed unless the Contractor has given the notice required in (a) above; provided, however, the time prescribed therefor may be extended by the Architect.

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c. No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

35. CODES AND STANDARDS

All work shall be performed per the following codes and standards.

a. Building Officials and Code Administrators (BOCA) International Inc. Basic Building Code

b. BOCA Basic Plumbing Code

c. BOCA Basic Mechanical Code

d. National Fire Protection Association (NFPA) 101 LIFE SAFETY CODE

e. National Electric Code (NEC)

f. Williams-Steiger Occupational Safety and Health Act of 1970 (OSHA)

g. American National Standard Safety Code for Elevators, Dumbwaiters, Escalators and Moving Walks as published by the American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI) A17.1

h. Air moving and Condition Association (AMCA)

i. American Concrete Institute (ACI)

j. American National Standards Institute (ANSI)

k. American Refrigeration Institute (ARI)

l. American Society for Testing and Materials (ASTM)

m. American Standards Association (ASA)

n. Cooling Tower Institute (CTI)

o. Institute of Electrical and Electronics Engineers (IEEE)

p. Insulated Power Cable Engineers Association (IPCEA)

q. Missouri Standard Specification for Highway Construction, Missouri State Highway Commission

r. National Board of Fire Underwriters (NBFU)

s. National Bureau of Standards (NBS)

t. National Electrical Manufactures Association (NEMA)

u. National Petroleum Institute (NPI)

v. Sheetmetal and Air Conditioning Contractors National Associations, Inc. (SMACNA), duct manual and sheetmetal construction for ventilation and air conditioning systems.

w. Underwriter's Laboratories, Inc. (UL), Federal Specifications

x. Safety Standard for Architectural Glazing Material (16 CFR 1201) issued by the Consumer Product Safety Commission 1-6-77 and effective 7-6-77.

The latest editions of these Codes and Standards shall be applicable unless otherwise designated. Where conflicts exist from one code to another, the more stringent requirement shall apply.

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How to Pick a Maintenance Management System*

C.K. Gold
C.K. Gold Associates

One of the most significant expenses to both Government and industry is facilities and equipment maintenance. On the average, over the lifetime of a building, operations and maintenance will be eight to ten times the cost of acquisition--and this ratio is climbing. Recent studies have shown that costs of labor intensive maintenance are growing at a higher rate than inflation, in fact doubling every four to five years.

The investment in facilities equipment may be thirty percent of the building acquisition costs and an even greater percent for firms with extensive production or research equipment. The overall investment in equipment can be the largest item of fixed costs. Clearly the efficient management of maintenance and operations merits close attention from decision makers.

There are two areas of concern: corrective maintenance (CM) and preventive maintenance (PM). Corrective maintenance is the **unscheduled**, unpredictable repair or emergency. Preventive maintenance is the **scheduled** inspection, adjustment, or minor repair to avoid an emergency or major breakdown.

Preventive maintenance (PM) is the most effective means of prolonging equipment usefulness and cutting down on repair cost. PM can reduce all the costs associated with equipment; that is, acquisition, repair, utilities, and production loss or downtime. Much depends, however, on the nature and amount of PM work performed. Too little preventive maintenance will not reduce repairs nor extend the life of the equipment. On the other hand, there is a point when added PM tasks no longer reduce the amount of repairs. A sound PM program must be developed, taking into account the realities of available personnel, hours, plant layout, and actual maintenance history on units of equipment as they exist in a given facility.

In short, the greatest promise for cost savings lies in the abilities of the manager to invest in PM, to prioritize repairs for the lowest overall cost of ownership, and to efficiently schedule and monitor the work of employees.

A complete Maintenance Management (MM) system will be able to handle four areas of management. These are Equipment Management; Building and Grounds Management; Inventory Management; and Project Management.

There are five steps or phases to establish and install a MM system.

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* Reprinted from 1983 Proceedings. Gold replaced another speaker at the last minute, for which APPA expresses its appreciation.

The first step is to determine what type of computer will be used. There are three options: micro, mini, or main-frame computers.

The computer size is determined by the size of files (the amount of data) necessary to be processed and the numbers of terminals (locations to input or receive information) necessary for a specific operation.

The files consist of the Parts Inventory; Equipment Inventory; and Maintenance History. The size of the Maintenance History File is determined by the desired length of time over which the history is needed.

The type of additional computer hardware required, if any, is based on any equipment or system already in place.

The manager must determine what excess information processing capabilities are available within their current system. Secondly, determine the number and the location of terminals and printers that would be available.

At this point, a decision can be made as to whether the MM system can be implemented within the current system. If it cannot, then additional compatible hardware must be acquired or a new system set up dedicated to the MM function.

Once the computer selection is made and the system is operational, the next step is to establish a data base.

This is the basic information about your equipment and plant site. It is to include everything that needs ongoing maintenance or that would be inspected, repaired or replaced.

A precise count of each item is taken that are electrical, electromechanical, mechanical, hydraulic, pneumatic or if it moves. Inspection activities are defined for roof, walls, painting, grounds, etc.

The Data Base must contain the following information for each unit of equipment:

1. unit number
2. unit description
3. site
4. building
5. floor
6. room
7. manufacturer
8. model number
9. serial number
10. building system of which unit is a component
11. building subsystem of which unit is a component
12. purchase vendor
13. purchase order number
14. cost
15. lease or purchase
16. warranty end date
17. date installed
18. date entered system

The Data Base must also contain the maintenance data that applies to each unit. The data should accommodate up to seven service levels. For each service level, list:

1. frequency of performance
2. maintenance vendor if contracted
3. type of pricing arrangement for maintenance contracts and price
4. task synopses for up to four employee tasks per service level
5. for each employee task list:
    a. craft/trade
    b. standard hours
    c. tools/equipment required
    d. material/parts required

The next phase is to assign the protocol (what is to be done) and the frequency (how often) to each item. For example, grease A units' belts every six months; inspect B units' belts every month.

Protocol and frequency is based on the age of the unit, its environment and the job it's assigned, as well as any regulatory requirements.

Work balancing is the next step.

To eliminate workload peaks and valleys, PM tasks are spaced over the entire year. This is done for each trade and for each type of equipment.

Work balancing takes into account how often the equipment is used and when it is used (seasonal or every day, etc.). Also specified is when the best times to work on the equipment occur, as well as any geographical differences.

The work is spread over a 52-week period to achieve the most efficient maintenance operation.

The next step is to establish your Miscellaneous Files. The Miscellaneous Files provide specific information to complete work orders (tools, material and wage information); and gives specific files from which you can sort (location, priority status, system, etc.).

Examples are:

Tools and Materials
Site, Building, Floor, Room
Craft/Trades
Employee - Wages, Shift, Overtime
Manufacturer/Vendor
Backlog Status
Priority
Condition
Action
Cause

The last step is to load the computer.

Once the MM system is installed, it will be able to perform the following tasks:

1. produce work orders (corrective and PM)
2. record inventory and data
3. track maintenance history
4. record service calls
5. record backlog work
6. provide reports as basis for budgets, staffing analysis, program evaluation, performance evaluation
7. provide an audit trail of work through service calls, backlog, work orders and maintenance history
8. provide flexibility in work planning, scheduling, and assignment
9. provide an interactive and on-line add, change and delete capability for data bases
10. provide real-time access to all programs and data
11. provide simple English language and user prompts for all required functions
12. provide detailed instructions for data collection and loading by the user
13. provide detailed user or operator instruction
14. be operable by a clerk
15. handle up to 10,000 units of equipment
16. retain on-line up to five years of detailed maintenance history
17. retain on-line summary maintenance history for the life of the unit
18. be able to select, sort, and list equipment information for the life of the unit
19. be able to select, sort, and list equipment information by unit, location (site, building and room), equipment owner, class of equipment, type of equipment, manufacturer
20. be able to access, sort and list maintenance history data by work order, unit, employee, type of service (e.g., repair, PM)
21. be able to access, sort and list data on personnel by employee and craft/trade
22. provide status of outstanding work orders
23. facilitate scheduling and assignment of work
24. operate on a 16 bit micro-computer with 256K internal memory, a 10 MB hard disk with both CRT and printer capability

PM work orders must be produced automatically that contain: a unique W/O number, the unit number, unit description, location, type of service being performed, a task synopsis, a list of tools, materials and parts required. There must be places for inserting the employee's name, work time required, if the work was completed, and comments. A separate PM W/O card must be produced for each employee (up to four employees) and for each service level. The PM W/O must also provide for the separate reporting of any minor repairs performed during PM performance.

PM W/Os are produced with a minimum user input data such as week number and location. They are sorted by location, building, floor, room and type of equipment and craft/trade. A weekly summary is produced and sorted chronologically including the type of service performed. The listing has a space for inserting the employee as signed and completion date.

Each W/O can be displayed or reproduced individually at any time.

The MM system automatically produces a Service Call Log. The Log records the name and phone number of the person requesting service, the reason for the call, unit number, date and time of call and the caller's opinion of priority for service.

A repair W/O is automatically issued from the Service Call Log or it is placed in the Backlog or Deferred Maintenance Files.

Service Call Log data does not have to be reentered for producing a W/O or moving it to the Backlog or Deferred Maintenance File. Service Calls can be printed or examined on the CRT. This data can be updated or changed interactively and on line.

Maintenance work which cannot be performed immediately can be transferred to the Backlog data base. The Backlog provides the following data on each work project: the unit number; service call number; priority; project status (up to 9); time and cost estimate; date entered in Backlog; and a description of the work required.

Backlog projects can be printed or examined on the CRT by priority or craft. This data can be changed or deleted either on line or interactively.

Repair W/Os are produced directly from the Service Call Log, Backlog, or from Deferred Maintenance. Repair W/Os contain: W/O number; unit number; unit description; location; complaint or work to be done; number of employees and the craft/trade required. Space is provided for the name of the employee, time worked, whether or not the work was completed, date completed. Also there is space for the **condition** of the unit, what **action** was taken and the probable **cause** of the problem as well as any comments.

There is a separate W/O card for each employee. All W/Os can be printed out or displayed on the CRT.

A Work in Progress (W-I-P) File is automatically created for all W/Os issued. This file contains: the unit number, W/O number; Service Call Log number; Backlog File number; complaint or service to be performed; and the phone number and name of the requestor. Other information that can be entered into the W-I-P File as the work progress is: the assigned employee; date assigned; work status; whether completed or not; date completed; time required; material costs; equipment condition, the action taken and the probable cause of the problem; and any other comments.

The W/O remains in the W-I-P File until it is either completed, cancelled or moved to Backlog and another W/O is issued to complete the work. This file can be printed out or examined on the CRT either in its entirety or by work status. W-I-P data can be updated or changed on line and interactively.

Once the W/O has been closed, this data is automatically transferred to the Maintenance History File. The Maintenance History File contains the following information about every W/O issued: the W/O number; unit number; work or service performed; employee(s) assigned; time required; completion date; Service Call numbers; Backlog number; unit condition, action taken and probable cause; comments; parts worked on or replaced and the material costs. It is the historical result of all information returned on a closed W/O. This history is only as detailed as the completed W/Os.

Maintenance History can be printed or examined on the CRT. It can be retained and available on line for five years or more.

In general, the MM system has a numerical geographic addressing scheme for all equipment that tracks site, building, floor and room. All equipment can be tracked to building systems or subsystems.

Maintenance costs based on time worked and the employee's wage rate are computed automatically.

All PM tasks can be handled in frequencies up to five years. These intervals can easily be changed.

The system differentiates between in-house and contracted work. To save money, equipment under warranty or contract maintenance is automatically flagged.

Even if equipment does not require PM, W/Os can be issued, statused and repair history can be retained for all equipment.

In simple English, PM W/Os are issued on a weekly basis and repair W/Os are issued at any time.

Overall, the PM management system can give the manager the following reports as needed for effective cost, personnel, and maintenance planning and control:

The **Equipment Inventory** lists the complete equipment information by site, building and room.

The **Master Equipment Record** matches the Equipment Inventory with the PM service level. This also gives the year to date grand totals for PM and repair hours as well as costs.

Maintenance History lists all W/Os, PM and repair, separately and in total in sorted order for each unit of equipment. This gives a clear picture of what services were performed, by whom, how long it took, the cost, what the problems were and the current condition of the unit.

The **Annual PM Work Plan**, for a given site, automatically calculates and lists for each week (up to 52 weeks) the hours of standard PM scheduled for each craft or trade. This report also gives the weekly and annual totals for each craft or trade.

The **Mean Time Between Failures Report** tells how long each unit is in service, how long it was down due to service, the number of repairs required, and what was the mean time between failures. The Average Down Time report gives the same information but also lists the average time between failures and the date the unit was placed back in service.

The **Repair Cost as a Percentage of Purchase Cost Report** red-flags all units whose repair costs exceed "X" percent of the purchase price. This report gives the unit description, manufacturer, model number, total repair cost to date, the date that record keeping started, the date the unit was installed, the days the unit was in operational condition and the purchase price of the unit.

The **Employee Performance Report** enumerates for each employee the actual number of hours worked versus a standard of PM hours. Total repair hours are listed. And the ratio of actual hours of PM worked versus standard PM hours content for the entire trade or craft is given.

For each group of units which have identical PM tasks, the **Repair/PM Ratio Report** identifies the total repair and PM costs and gives the ratio.

Each week a **W-I-P Summary for PM W/Os** is issued that tells the number of W/Os issued and assigned, how many were completed showing both standard hours and actual hours. This report also shows the total of PM standard hours assigned but not completed and the total PM standard hours of W/Os not assigned.

Similarly, each week a **W-I-P Summary for Repair W/Os** is issued. This lists the number of W/Os issued, assigned and how many were completed. Those issued but not assigned, as well as those assigned but not completed, are also listed.

Finally, the **Repair/Failure Analysis Report** is given by unit and class of equipment for a specified time period. This analysis lists the number of repairs made for each type of repair. Some examples of repair type are: calibrate, adjust, replace. Listings are made by Action, Cause and Condition.

A **Work Management Program** will control all work orders pertaining to building and grounds. It will produce PM and CM W/Os and create a Maintenance History File. Report generating would be available as in the Equipment Management Program.

A **Project Management System** would allow the user to charge multiple work orders and inventory to a single cost center for cost tracking and planning.

And, lastly, an **Inventory Management System** that is interactive. It would charge to W/Os and maintenance history, keep up-to-date records of inventory items, and advise the user of order levels and the last three successful vendors.

In conclusion, a well-executed MM system allows management to bring more equipment and plant site under attention without hiring more staff.

Because of better planning, building and renovation programs are kept up to date. Thus, the most efficient work methods are utilized.

PM work on given equipment is performed at the correct time with the specified tasks.

Because the data is organized hierarchically and prioritized by the manager, all technical details of the entire building facility and plant are available at once. This enables the manager to get a clear and instantaneous picture of the conditions at all times.

Personnel are better utilized because of optimal scheduling. New personnel are more easily trained. Improved organization results in better morale. Success breeds success.

In the overview, the manager better knows what is being done, by whom, how much it costs, and has complete documentation to prove it!

Incineration: State-of-the-Art Design, Procurement & Operations

by Lawrence G. Doucet, P.E.
Doucet & Mainka, P.C.

INTRODUCTION

On-site incineration has become an increasingly important method for the treatment and disposal of wastes from universities, colleges, medical centers, hospitals and similar types of institutions. This can largely be attributed to such factors as rising off-site disposal costs, the potential for recovering energy from the incineration process, the recent promulgations of hazardous waste disposal regulations and proven, technological advancements in incineration. Properly designed and operated systems are capable of complying with stringent environmental regulations and demanding performance requirements. Incineration can reduce the weight and volume of solid waste as much as 95 percent. Furthermore, it provides prompt sterilization and detoxification of "special" wastes, such as infectious, pathological, chemical solvents and low-level radioactive materials.

By far, the most widely and extensively used incineration technology over the past decade is "controlled air" incineration. This has also been called "starved-air" incineration, "two-stage" incineration, "modular" combustion and "pyrolytic" combustion. On the order of 7,000 controlled air type systems have been installed by approximately two dozen manufacturers over the past two decades. Almost every new system being installed at universities, colleges, hospitals and similar institutions is a controlled air design. More than 75 percent of these are being equipped with waste heat recovery boilers. Also, an increasing number of systems are being equipped to burn spent chemical solvents in conjuction with solid wastes.

Controlled air incineration is the least costly incineration technology - a factor which has greatly influenced its popularity. Most systems are offered as "pre-engineered", prefabricated units with low capital cost requirements. Operating costs are also low, since air pollution control equipment is seldom required.

However, despite its growing importance and advancements, controlled air incineration has established a somewhat questionable track-record. There are literally hundreds of installations which perform poorly or not at all. It has been estimated that the success rate for controlled air incineration systems is only about 75 percent. In other words, about 25 percent of all new systems, according to statistics, do not operate properly.

The objectives of this paper are threefold:

1. To present a brief overview of state-of-the-art controlled air incineration technology.

2. To present a recommended outline or approach, which has a high probability of procuring a "good", or successful, and cost-effective controlled air incineration system.

3. To discuss various issues and concepts relative to selecting, designing, evaluating and operating a controlled air incineration system.

CONTROLLED AIR INCINERATION TECHNOLOGY

Background

Gordon Hoskinson, known as the founder of controlled air incineration, had difficulties promoting his system until he placed a full-page ad in the New York Times in 1962. His announcement of the "Hoskinson Smokeless Incinerator" attracted several investors who, in 1964, formed the company of Smokatrol. The controlled air industry grew slowly at first. However, roughly every five years it has gone through periods of extraordinary expansion. In the late 1960's growth was attributable to the Clean Air Acts, in the early and late 1970's the Arab Oil embargos, and, recently, due to Hazardous Waste Disposal Regulations. These growth periods have each seen the proliferation of literally scores of new vendors and equipment suppliers. Most of these, however, have been "backyard" establishments which have lasted for only short periods of time. Increased competition and rapid changes in the technology and market structure have forced most of the smaller and less progressive companies to close. Generally, the industry has been in a state of almost constant development and change, with frequent turnover of firms, mergers and failures.

Today, there are approximately a dozen manufacturers of controlled air incinerators. However, only about half of these have an established, successful track-record with demonstrated capabilities and qualifications for providing first-quality installations.

There have been many major developments and improvements in controlled air incineration since the technology was first marketed commercially in the early 1960's. Most of these efforts have been and are still directed towards:

- Increased capacity and flexibility, primarily through the development of automatic loading devices and continuous automatic residue removal systems.

- Improved combustion control techniques to reduce both operational problems and emission levels.

- Development of devices and systems to provide better protection for personnel and equipment.

- Increased automation to minimize operator judgement and input

- Development of better heat recovery systems and techniques.

Principles of Design & Control

Controlled air incineration is basically a simple process utilizing two-stage, modulated combustion conditions to maximize burning efficiencies and waste destruction while minimizing stack emissions. The first-stage consists of a "primary combustion chamber" into which waste materials are loaded and burned in an oxygen deficient, or starved-air environment. The second-stage consists of a "secondary combustion chamber" which is operated under excess air conditions and provides for the complete destruction of smoke, volatile gases and carbonaceous particles exiting the primary combustion chamber. Combustion air supply to both chambers is usually automatically regulated, or controlled, to maintain optimum combustion conditions as waste loading rates, compositions and characteristics vary. Properly designed, controlled and operated systems have such extremely low stack emission levels that air pollution control equipment is not needed for regulatory compliance. Low emissions and small excess air quantities combine to increase the feasibilities of heat recovery.

Until recently, most controlled air incinerators were essentially uncontrolled air incinerators. Combustion air flow and cycle timing were designed, adjusted and set by the manufacturer to suit an "average" range of waste characteristics and feeding rates. When waste types and charging rates varied significantly from the design range, poor performance and operating problems would result.

In fact, even when waste type and charging rates were maintained reasonably within the pre-selected design limits, radical, detrimental variations in temperature and gas flow would often be a normal occurrence. For example, a charge of highly volatile materials, such as polyester fibers, could cause the temperatures in an unmodulated furnace to increase as much as 1000° Fahrenheit and gas flows to increase as much as 50 percent in less than a minute. Pulses of volatiles to the secondary chamber could reach as high as 200 percent of design conditions shortly after a typical load was charged.

Modern controlled air incinerators are equipped with air supply dampers for regulating air/fuel ratios to maintain stablized combustion conditions. Damper operation is usually factory set to modulate open and close between fixed limit points. Some manufacturers employ a single butterfly damper in the discharge duct from a single blower to proportion air between the primary and secondary chambers. Other manufacturers provide separate primary and secondary blowers with a butterfly damper on each.

Damper operation for most controlled air units is modulated on the basis of primary chamber gas temperatures. Increasing temperatures signal the air dampers to reduce primary air supply in order to decrease the rate of combustion, or oxidation. Conversely, decreasing temperatures signal the dampers to increase primary air supply to increase the rate of combustion.

Secondary air is directly related to primary air supply. Since the total required combustion air supply, including about 100 percent excess, is provided in a balanced ratio between the primary and secondary chambers, the secondary air is designed to change inversely to primary air. In other words, an increase in primary temperature reduces the primary air and increases the secondary air; or conversely, increasing primary air reduces secondary air.

Sizing and Rating

Primary chamber sizing

Mixtures of wastes most commonly encountered have been classified and their average characteristics, including ash, moisture and heating value, have been categorized. Of several classification systems available, that published in "Incinerator Standards" by the now defuct Incinerator Institute of America is the virtual standard. In this system, shown on Table 1, wastes are classified into six types. Types 0 through 4 are mixtures of typical, general waste materials, and Types 5 and 6 are industrial wastes which require special analysis.

The capacity of controlled air incinerators is usually rated in pounds of a specific waste type, usually Type 0 through 4, which can be burned per hour. Since each of the waste types has a different heating value, an incinerator will have several different capacity ratings. For example, an incinerator that typically handles 1600 pounds/hour of Type 1 waste will process no more than about 1230 pounds/hour of Type 0, and no more than about 825 pounds/hour of Type 4 waste.

These limitations and rating variations exist because most manufacturers size chamber volumes on the basis of internal heat release rates, or heat concentrations. Typical maximum values are on the order of 20,000 to 25,000 Btu/cubic-feet/hour.

Since pathological waste, Type 4, has a heat content of only 1000 Btu/pound, it might be assumed that an even higher rating could be obtained. However, this is not the case. The heat input required by an auxiliary fuel burner to vaporize the high moisture content of Types 3 and 4 wastes reduces the capacity rates.

Secondary chamber sizing

Secondary chambers of controlled air incinerators are generally sized to provide sufficient Time, Temperature and Turbulence (three T's of combustion) for the complete burnout of combustibles in the flue gases from the primary chamber. They are generally designed to operate with up to 200 percent excess air and provide:

- Gas retention times ranging from 0.5 to 2.0 seconds.

- Combustion temperatures ranging from 1400° to 1800° Fahrenheit, typically 1600° Fahrenheit.

- Turbulent mixing of gas and air through the use of high velocity air injection, abrupt changes in direction, internal checkerwork or refractory orifices.

Furnace geometry

The shape of the primary and secondary chambers is not critical as long as the requirements for heat release, retention times and optimum air distribution are satisfied. Rather, chamber geometry is most affected by manufacturing and transport considerations.

Most primary furnaces are cylindically shaped, with units sized for less than about 500 pound/hour capacity usually vertically oriented, and the larger units horizontally oriented. This is not always the case, as several controlled air manufacturers fabricate units using rectangular box-like shapes.

Variations

At least several controlled air manufacturers offer systems with a third stage, or tertiary chamber following the customary second stage. One manufacturer offers a system with three stages of air control, but with two combustion chambers. Also, one manufacturer offers a fourth stage, termed a "reburn tunnel", which is used to condition gases upstream of the heat recovery boiler.

These variations, among others, represent attempts to improve efficiencies and performance. However, proper design, control and operations of the first two stages are the overall keys to success.

Auxiliary Systems

Charging systems

Most controlled air incinerators with capacities less than 200 pound/hour are available only with manual loading devices. Units with capacities in the 200 to 500 pound/hour range can usually be provided with mechanical loaders as a special option. Mechanical loaders are almost always included for units processing more than 500 pound/hour.

The use of mechanical loading devices enables controlled air incinerators to be charged with small batches of waste at frequent, regulated time intervals. This mode of operation is desirable for several reasons:

- Stabilization of furnace conditions by approximating continuous, steady-state operation.
- Protection against over-charging.
- Reduction of fire hazards
- Provision for integration with automatic waste handling systems.

Mechanical loaders also serve as air-lock devices to prevent the exfiltration of combustion products and heat from the furnace, as well as prevent ambient infiltrations into the furnace. Excess infiltration could cause smoking, refractory deterioration and excessive supplemental fuel usage.

The development of mechanical loading devices has been a major element in modernizing controlled air incineration technology. The earliest controlled air units were all restricted to manual charging, a feature which limited their capacity and resulted in various operating and emissions problems. Early generations of charging devices were crudely constructed and had many design deficiencies which caused serious fire and smoke problems.

The development of safe, reliable charging systems has taken many years. Of the several loader designs currently available, the "hopper/ram assembly" has become standard for most controlled air incinerators. With this system, waste is loaded into a hopper, the hopper cover closes, a fire door opens, and a ram then pushes the waste into the primary chamber.

Most modern hopper/ram assemblies are provided with a water system to quench the face of the charging ram after every cycle. This prevents the ram from becoming overheated by constant, direct exposure to the furnace flames. Without cooling, the ram face would eventually overheat and become a fire hazard in itself.

The cart-dumping loader, basically combines a standard hopper/ram assembly with a mechanism for automatically dumping waste carts. The cart volumes are matched to the loader volumes, with the latter approximately one-third greater to facilitate transfer of waste material from cart to loader. Collection carts are convenient because they eliminate both unnecessary waste handling and the need for intermediate containers.

Residue removal systems

Manual removal of residue, or ash, following a cool-down period, is the clean-out method used for nearly all controlled air incinerators. This generally entails the use of hoes, shovels, barrels and wheelbarrows. Small capacity controlled air units are cleaned from the outside. However, large capacity units require that the operator enter the incinerator and shovel ashes into barrels or tubs. One practice for very large outdoor incinerator units has been to utilize a special vehicular mounted hoe for pulling ashes out onto the ground.

Residue removal, in general, has always been a particular problem for controlled air incineration facilities, and the practice of manual clean-out is especially objectionable from many aspects:

- Increased labor requirements.

- Hazardous to operating personnel because of hot walls, pockets of glowing ash, dust and noxious gases.

- Cool-down time requirements which reduce available charging time.

- Daily cool-down and start-up cycling, which could increase auxiliary fuel requirements by more than one-third.

- Detrimental effect of thermal cycling on furnace refractory.

- Dusting outside the furnace which could result in severe aesthetic or environmental problems.

- Potential fire hazard from the handling of unquenched ashes.

Early attempts with automatic residue removal utilized a bomb-bay door concept. Basically, the bottom of the primary furnace would open to drop residue into a container or vehicle located below. Serious operating problems led to the discontinuance of this system.

More recent ash removal techniques have involved the use of special rams or plungers designed to "push" the mass of residue across the primary chamber hearth and out a discharge door or opening. However, these systems have had only limited success, at best.

The automatic residue removal system that has shown the most promise, and that has been demonstrated successfully in actual application, utilizes the waste charging ram to force waste and residue through the furnace. The waste is reduced to ash by the time it reaches the opposite end of the chamber. Incinerators with capacities in exess of about 800-1000 pound/hour typically utilize one or more internal transfer rams to convey ashes through the furnace to the drop chute.

The most innovative residue removal system utilizes a "pulse hearth" to transfer ash through the furnace. The entire floor of the primary chamber is suspended on cables and intermittently pulsed on the ends via air cushions. Inertial forces cause material movement across the hearth. Several successful installations utilize this technique.

After the ash residues drop from the primary chamber through a discharge chute, there are two systems for collecting and transporting them from the facility. The first is a semi-automatic system utilizing ash collection carts within an air-sealed enclosure. Ash falling into these carts is sprayed for dust suppression. The second method is to utilize a fully-automatic system comprising a water quench trough and heavy-duty, ash conveyor. These systems are of superior quality, but are very costly. They are difficult to justify for incinerators which operate less than 24 hours per day or which have a charging rate of less than about 2000 pound per hour.

Fuel Economy Features

Various techniques and devices have been employed in attempts to reduce or minimize auxiliary fuel requirements. These include:

- Secondary Chamber Air Modulation

One of the most significant recent innovations has been to provide secondary chamber air modulation. Incinerators equipped with secondary air modulation operate effectively over a wider range of loading/heat content conditions without requiring excessive secondary chamber fuel input.

- Air Heater

Some controlled air units are available with airheaters for reducing fuel consumption. These consist of jacketed shells around the primary and/or secondary chambers for preheating combustion air. The air, which is pulled through the jacketed shell by the air supply blower, is increased in temperature by as much as several hundred degrees.

- Burner Modulation

Most recently constructed controlled air incinerators are provided with modulating burners, set to modulate between minimum and maximum values for reducing fuel consumption. However, burner modulation is set to follow the responses of air modulation, which is the priority control function.

Energy recovery

Energy recovery in controlled air incinerators is accomplished by the convective transfer of the sensible heat contained in the flue gases. The greatest potential and most direct approach is the generation of steam or HTW in a heat recovery, or waste heat boiler. Steam is a widely used energy source which is versatile in application capabilities. Both firetube and watertube boilers have been utilized successfully with controlled air incinerators, and recovery efficiencies range from 50 to 70 percent, averaging near 60 percent. Typically, 7800 pounds of steam is recoverable per ton of Type 1 waste at a 60 percent recovery efficiency. The steam is available at any reasonable pressure, dependent upon the user's needs.

Most controlled air incinerator manufacturers use firetube boilers for heat recovery. They have a substantially lower first cost than watertube boilers, but generally are limited to lower steam pressures and generating rates.

Watertube waste heat boilers are available in single and multi-drum natural circulation types and forced circulation types. The type of watertube boiler which has been most successfully applied to controlled air incinerators is the single-drum, natural circulating type, originally developed and utilized in the exhaust from industrial and commercial gas turbines.

One manufacurer offers systems with a waterwall radiant section in the primary chamber in series with a convective boiler. A 15 percent increase in recovery efficiency is claimed.

The amount of energy which can be extracted depends upon the amount of energy in the hot gas stream, which mainly is a function of the gas mass flow and temperature. The conventional limits which govern system performance are heat exchanger inlet and outlet temperatures and pressure drop. Inlet temperatures are typically limited to a maximum of 1800° Fahrenheit, for structural reasons, and the outlet temperature is maintained above 400° Fahreheit, to minimize dew point corrosion problems.

Components of a typical heat recovery system include the heat exchanger, by-pass or abort arrangement, draft inducer, soot-blowing or tube cleaning systems, breeching and stack, controls, condensate receiver, and, possibly, supplemental fuel firing.

PROBLEM INCINERATION SYSTEMS & THEIR CAUSES

As discussed, roughly one in four controlled air systems operate poorly. Although there are many trouble-free systems, "good" incineration performance is viewed by many as the exception rather than the rule.

Some of the most typical problems reported for incineration systems include:

- Inability to burn wastes at required capacity
- Poor burnout, or destruction, of waste materials
- Smoking from the stack
- Smoke and occasional fires in incinerator room areas
- Costly repairs and associated frequent downtimes

These problems are interrelated, and they usually occur in combinations. They occur as frequently and as extensively in small, dedicated facilities as in large, complex facilities. Also, they may range in severity from objectionable nuissances to major disabilities, and corrective needs may range from minor adjustments to major modifications or even total abandonment.

Underlying causes or reasons for problem incineration systems are not always obvious. They may be the result of deficiencies or inadequacies in any or all of three areas:

1. System selection and/or design deficiencies -

Includes insufficient or incorrect waste data, improper capacity selection, or inadequate design or construction criteria.

2. Fabrication and/or installation deficiencies -

Includes inferior, or substandard workmanship or quality, as well as failure of the incinerator contractor to comply with specified criteria and requirements.

3. Operating and/or maintenance deficiencies -

Includes improper operational procedures or negligent maintenance, care or adjustments to the system and equipment.

Selection and design deficiencies are probably the most common as well as the most serious causes of problem incineration systems. Reputable incinerator contractors typically make every effort to satisfy specified design and construction criteria, as per contractural obligations. Operating and maintenance deficiencies can usually be corrected. However, once a system has been installed and started up, very little can be done to compensate for fundamental design inadequacies. Major, costly modifications and revisions to performance objectives are usually required.

The relative frequent occurance of design deficient related problem systems may be largely attributable to a general misconception of the controlled air incineration industry. Controlled air incinerators are largely promoted as standard, off-the-shelf equipment that can be ordered from basic catalogs, shipped to almost any job site and, literally, "plugged in". This impression is enhanced by many of the incinerator vendors in a fiercely competitive market. Exaggerations, half-truths and,sometimes, false claims abound relative to equipment capabilities and performance. Attractive, impressive brochures illustrate a basic simplicity to the selection of a controlled air system for satisfying any requirement.

In light of the above, a first step towards procuring a "good", incineration system is to view the controlled air industry in a proper perspective. In this regard, there are four basic principles to bear in mind:

1. Incineration technology is not an exact science

It is still more of an art than a science, and there are no assured shortcuts, simplistic methods or textbook formulas for success.

2. There is no "universal" incinerator

No design is universally suited for all applications. Incinerators must be specifically selected, designed and constructed for the needs of each facility on an individual basis. Manufacturers catalogs identify typical models and sizes, but these are rarely adequate for most facilities without special provisions or modifications.

3. There is no "typical" incinerator application

Even facilities of similar type, size and activities have wide differences in such parameters as waste types and quantities, waste management practices, disposal costs, space availability and code requirements. Each application has unique incineration system requirements which must be identified and accommodated on an individual basis.

4. Incinerator manufacturers are not equal

There are wide differences in reputabilities, capabilities and qualifications of the incinerator equipment manufacturers. Likewise, there are wide differences in their systems and equipment.

RECOMMENDED SYSTEM IMPLEMENTATION

Five,general steps, or phases, involved with the implementation, or procurement, of incineration systems, are outlined on Table 2, Recommended Incineration System Implementation, and include:

(1) Feasibility evaluation & selection, (2) Design documents, (3) Contractor evaluation & selection, (4) Construction, and (5) Startup and final acceptance.

Unfortunately, on most projects, the first three steps are given minimal attention, if not disregarded entirely. Consequently, completion of the startup and final acceptance phase, step 5, often proves unsuccessful.

As previously discussed, selection and design are fundamental for procuring a successful installation. However, most system design documents comprise no more than "Purchase Orders" with generalized requirements such as:

> Furnish complete incineration/heat recovery system to burn 1000 lb/hr of trash in compliance with all applicable regulations.

Obviously, the chances for success are marginal for any incineration system procured on the basis of such a specification.

Good incineration system design specifications, which are included under step 2, design document phase, should be complete and comprehensive. They should indicate the performance requirements, design and construction criteria for all equipment and appurtenances, including not only the incinerator, but also such items as waste and ash handling equipment, supplemental fuel system, waste heat boiler and feedwater system, breeching and stack system, by-pass and draft control dampers and controls and instrumentation. The specification should also include specific obligations of the incinerator contractor, ranging from delivery of equipment through installation, startup, performance testing and operator training. Furthermore, it may also be necessary to specify requirements relative to other work associated with the incinerator contractor's work, such as piping and wiring, room ventilation and lighting systems, miscellaneous metal work and equipment supports. A recommended "General Outline Specification and Checklist" is attached for guidance.

On most projects, incinerator contractor evaluation and selection, step 3, involves no more than solicitation of prices from a random listing of incinerator vendors and the award of a contract to that firm proposing a "system" for the least cost. There are two basic problems with this approach. First, the selected incinerator vendors are assumed to have equivalent capabilities and qualifications. Second, "least cost" acceptance assumes that the equipment offered by each of the vendors is equivalent, or identical. However, a proper "value" assessment of the proposals, coupled with good design documents, often results in the procurement of a superior system for a negligible price difference. It is not uncommon to see a cost proposal "low" by no more than 10 percent, but the equipment offered only about half the quality of the competition.

Although there are no guaranteed formulas, the probabilities of procuring a "good", cost-effective incineration system increases proportionally [illegible]h the attention and efforts given to each of the five implementation phases outlined on Table 2.

ADDITIONAL FACTORS AND CONSIDERATIONS

Waste data

Highly accurate waste characterization and quantification data are not always required for designing and selecting incineration systems. However, vague or incomplete data can be very misleading and result in serious problems.

Waste characterization involves identification of individual waste constituents, relevant physical and chemical properties and hazardous parameters. There are a number of terms that are commonly used to characterize waste materials which can be very misleading when used in specifications. For example, vague terms such as "general waste", "trash", "biological waste", "infectious waste", and "solid waste", provide little information about the nature or characteristics of the waste materials.

Waste characterization efforts can range from simple approximations to complex and costly sampling and analytical programs. A frequently used approximation method is to categorize average waste mixtures into five classes of types, Types 0 through 4, as discussed above. The popularity of this waste classification system is enhanced by the fact that most of the incinerator manufacturers rate their equipment in terms of these waste types. However, it should be noted that actual "average" waste mixtures rarely have the exact characteristics delineated for any of these indicated waste "Types".

The other end of the characterization spectrum involves costly laboratory analysis of specific representative, waste samples in order to determine "exact" heating values, moisture content, ash content and the like. Such testing has been undertaken at various institutions because of specific considerations and advice. However, this approach is generally not recommended. It is too costly and provides no significant benefit over other acceptable approximation methods.

Virtually all components found in typical university and hospital solid wastes have been sufficiently well characterized in various engineering textbooks, handbooks and other technical publications. An example is presented on Table 3, Typical Waste Data. In many cases, a reasonably accurate compositional analysis of the waste mix, in conjunction with such published information, could provide relatively reliable and useful characterization data.

A critical concept relative to waste characterization is that incineration systems must be designed to handle the "extremes", or ranges, of the waste feed properties - not the "average". System capacity and performance may be inadequate if the waste data does not indicate such ranges.

Waste quantification data is one of the primary criteria for selecting incineration system capacity. Such data should include not only average waste generation rates, but also peak rates and fluctuation cycles. The most accurate method of determining such data is a comprehensive weighing program over a period of about two weeks. However, the most common procedure has been to estimate waste quantities from the number and volume of waste containers hauled from the facility to land disposal. Large errors have resulted from such estimates because of failures to account for container compaction densities or from faulty assumptions that the waste containers were always fully loaded.

Incinerator Capacity Determination

There are three major variables which affect the selection of incineration system capacity, or hourly burning rate:

(1) Waste generation rates, (2) Waste types, forms and sizes, (3) Operating hours. These are discussed below:

1. Waste generation rates

As discussed above, waste quantification data serves as a primary basis for selecting incineration system capacity. However, when waste generation rates are grossly under-estimated, incineration capacity is usually inadequate for planned, or available, periods of operation. In such cases, the tendency is to over-load the system, and, of course, operational problems ensue. On the other hand, grossly over-estimating waste generation rates can be equally bad. If waste heat recovery is necessary to justify system economics, insufficient waste quantities could be a serious problem. Also, since incineration systems must be operated near their rated capacities for good performance and efficiency, an oversized system would have less hours per day available for operation. Such reduced operating hours could be a severe problem with respect to waste handling operations, particularly if waste storage areas are marginal.

2. Waste types, forms and sizes

Since incinerators are primarily sized according to heat release rates (Btu/cu-ft/hr), waste heat value is a fundamental determinant of capacity. For example, to maintain a constant heat release when waste heating values (Btu's) increase, proportionally less quantities (lbs) must be loaded. However, the physical form, or consistency ,of waste may have a far more significant impact on burning capacities. For example, densely packed papers, books, catalogs and the like, may have an effective incinerability factor of only about 20 percent compared to burning loosely packed paper similar to Type 1 waste. Also, wastes similar to animal bedding, or cage wastes, have high ash formation tendencies which reduce burning rates substantially. Highly volatile wastes, such as plastics may require reduced burning rates to prevent smoking problems.

The physical sizes of individual waste items and containers is also an important factor in the selection of incineration capacity. One rule-of-thumb is that the average incinerator waste load, or largest item, should weigh approximately ten percent of rated, hourly system capacity. However, loads of highly volatile items, such as plastics, should weigh much less. On this basis, a nominal 200 pound/hour incinerator would be required for, say, Type 1 waste materials packaged in up to about 20 pound containers or bags. This would be so regardless of the total daily quantity of Type 1 waste requiring incineration.

3. Operating hours

A typical daily operating cycle for a controlled air incinerator without automatic ash removal is as follows:

Steps	Typical Durations
• Clean-out	15 - 30 minutes
• Pre-heat	15 - 60 minutes
• Waste loading	12 - 14 hours
• Burn-down	2 - 4 hours
• Cool-down	5 - 8 hours

It is important to note that actual waste loading is limited to 12 to 14 hours per operating day.

Basic Incinerator Design Parameters

Although incinerator systems require complex engineering, several criteria can be readily applied in their specification, comparison or evaluation and selection. These are as follows:

- Primary chamber heat release - As discussed above, this criteria basically establishes primary furnace volume for a specific waste type and charging rate. Heat release values (Btu/cu-ft/hr) are simply determined by multiplying charging rate (lb/hr) by heating value (Btu/lb) and dividing by primary volume (cu-ft). Based upon accepted, empirical values, heat release rates should be in the range of about 15,000 to 25,000. Table 4 indicates approximate primary chamber volumetric requirements for various waste types at these two values.

- Primary chamber burning rate - This criteria generally establishes burning surface, or hearth area, sizing in the primary chamber. It limits the maximum pounds of waste which should be burned per square foot of projected surface area per hour (lb/sq-ft/hr). Table 5 indicates recommended maximum burning rates for various waste types. These rates are based upon empirical data as published by the Incinerator Institute of America.

- Secondary chamber retention time - As discussed, secondary chambers provide for the combustion of smoke, carbonaceous particulates and unburned hydrocarbons which are exhausted from the primary chamber. The duration which these gases are retained is termed retention time. This is determined by dividing secondary chamber volume (cu-ft) by the volumetric flue gas flow rate (actual cu-ft/sec). Flue gas volumes are basically a function of waste type, excess combustion air and temperatures. They can be calculated or measured. However, during normal incinerator operations, flue gas flow rates vary widely and frequently

Table 6 indicates typical secondary chamber requirements for various waste types to provide one second of retention time. Note, however, these are based on assumed operating temperatures and excess air values.

OPERATION AND MAINTENANCE

Incineration systems are normally subject to extremely severe operating conditions. These include very high and widely fluctuating temperatures, thermal shock from wet materials, slagging residues which clinker and spall furnace materials, explosions from items such as aerosol cans and ether bottles, corrosive attacks from acid gases and chemicals and mechanical abrasion from the movement of waste materials and from operating tools. These conditions are compounded by the complexity of the incineration process. Combustion processes are complicated in themselves, but in incineration this complexity is magnified by frequent, unpredictable and often tremendous variations in waste composition and feed rates. To properly manage such severe and complex operating conditions, incineration systems require well-trained, dedicated operating personnel, frequent and thorough inspections, maintenance and repair, and administrative and supervisory personnel attuned to these requirements.

The best designed, most sophisticated and highest quality incineration system is usually no better than the operating personnel assigned to it. Ill-trained and uncaring operators have no difficulties in debilitating system performance or causing rapid shutdowns. The employment of properly trained and well-supervised operating personnel is an effective method for maintaining good incineration system performance over the expected life of the equipment.

At many facilities, the practice is to operate the incineration system continuously until it breaks down because of equipment failures. This type of operation not only causes acceleratingly bad performance, but also rapid and severe equipment deterioration. Repairs done after such breakdowns are usually far more extensive and costly than those performed during routine preventative maintenance procedures. Also, items which are typically capable of lasting many years can fail in a fraction of that time if interrelated components are permitted to fail completely.

LIST OF TABLES

1. INCINERATOR INSTITUTE OF AMERICA SOLID WASTE CLASSIFICATIONS
2. RECOMMENDED INCINERATION SYSTEM IMPLEMENTATION
3. WASTE DATA CHART
4. PRIMARY COMBUSTION CHAMBER VOLUMETRIC GUIDELINES
5. PRIMARY COMBUSTION CHAMBER HEARTH BURNING RATE GUIDELINES
6. SECONDARY COMBUSTION CHAMBER VOLUMETRIC GUIDELINES
7. GENERAL OUTLINE SPECIFICATION AND CHECKLIST FOR INCINERATION SYSTEM WITH HEAT RECOVERY

TABLE 1

INCINERATOR INSTITUTE OF AMERICA
SOLID WASTE CLASSIFICATIONS

Type 0—Trash, a mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes, and combustible floor sweepings, from commercial and industrial activities. The mixtures contain up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps.

This type of waste contains 10% moisture, 5% incombustible solids and has a heating value of 8500 B.T.U. per pound as fired.

Type 1—Rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scrap, foliage and combustible floor sweepings, from domestic, commercial and industrial activities. The mixture contains up to 20% by weight of restaurant or cafeteria waste, but contains little or no treated papers, plastic or rubber wastes.

This type of waste contains 25% moisture, 10% incombustible solids and has a heating value of 6500 B.T.U. per pound as fired.

Type 2—Refuse, consisting of an approximately even mixture of rubbish and garbage by weight.

This type of waste is common to apartment and residential occupancy, consisting of up to 50% moisture, 7% incombustible solids, and has a heating value of 4300 B.T.U. per pound as fired.

Type 3—Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets, and like installations.

This type of waste contains up to 70% moisture, up to 5% incombustible solids, and has a heating value of 2500 B.T.U. per pound as fired.

Type 4—Human and animal remains, consisting of carcasses, organs and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85% moisture, 5% incombustible solids, and having a heating value of 1000 B.T.U. per pound as fired.

Type 5—By-product waste, gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludge, fumes, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

Type 6—Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

TABLE 2

RECOMMENDED INCINERATION SYSTEM IMPLEMENTATION

1. FEASIBILITY EVALUATION & SELECTIONS

   A. Data collection and organization: waste, costs, utilities, codes and regulations

   B. Engineering calculations and analysis

   C. Identification of options and alternatives

   D. Siting feasibilities and comparisons

   E. Economic analysis: preliminary capital, annual and life-cycle costs estimates

2. DESIGN DOCUMENTS

   Preliminary and final drawing and specifications for bidding, procurement, installation and startup

3. CONTRACTOR EVALUATION AND SELECTION

   A. Bid solicitations to prequalified incinerator contractors

   B. Bid and proposal evaluaitons and analysis

   C. Negotiations and contract award

4. CONSTRUCTION

   A. Building, site and general construction work

   B. System and equipment installation

5. STARTUP AND FINAL ACCEPTANCE

   A. System shakedown and final punchout

   B. Testing: operational, performance and emissions tests

   C. Permitting: Certificate of Operation

   D. Operator training

   E. Final acceptance by owner

TABLE 3

WASTE DATA CHART

Material	B.T.U. value/lb. as fired	Wt. in lbs. per cu. ft. (loose)	Wt. in lbs. per cu. ft.	Content by weight in percentage	
				ASH	MOISTURE
Type 0 Waste	8,500	8-10		5	10
Type 1 Waste	6,500	8-10		10	25
Type 2 Waste	4,300	15-20		7	50
Type 3 Waste	2,500	30-35		5	70
Type 4 Waste	1,000	45-55		5	85
Acetic Acid	6,280		65.8	0.5	0
Animal fats	17,000	50-60		0	0
Benzene	18,210		55	0.5	0
Brown paper	7,250	7		1	6
Butyl sole composition	10,900	25		30	1
Carbon	14,093		138	0	0
Citrus rinds	1,700	40		0.75	75
Coated milk cartons	11,330	5		1	3.5
Coffee grounds	10,000	25-30		2	20
Corn cobs	8,000	10-15		3	5
Corrugated paper	7,040	7		5	5
Cotton seed hulls	8,600	25-30		2	10
Ethyl Alcohol	13,325		49.3	0	0
Hydrogen	61,000		0.0053	0	0
Kerosene	18,900		50	0.5	0
Latex	10,000	45	45	0	0
Linoleum scrap	11,000	70-100		20-30	1
Magazines	5,250	35-50		22.5	5
Methyl alcohol	10,250		49.6	0	0
Naphtha	15,000		41.6	0	0
Newspaper	7,975	7		1.5	6
Plastic coated paper	7,340	7		2.6	5
Polyethylene	20,000	40-60	60	0	0
Polyurethane (foamed)	13,000	2	2	0	0
Rags (linen or cotton)	7,200	10-15		2	5
Rags (silk or wool)	8,400-8,900	10-15		2	5
Rubber waste	9,000-11,000	62-125		20-30	0
Shoe Leather	7,240	20		21	7.5
Tar or asphalt	17,000	60		1	0
Tar paper ⅓ tar-⅔ paper	11,000	10-20		2	1
Toluene	18,440		52	0.5	0
Turpentine	17,000		53.6	0	0
⅓ wax-⅔ paper	11,500	7-10		3	1
Wax paraffin	18,621		54-57	0	0
Wood bark	8,000-9,000	12-20		3	10
Wood bark (fir)	9,500	12-20		3	10
Wood sawdust	7,800-8.500	10-12		3	10
Wood sawdust (pine)	9,600	10-12		3	10

The above chart shows the various B.T.U. values of materials commonly encountered in incinerator designs. The values given are approximate and may vary based on their exact characteristics or moisture content.

TABLE 4

PRIMARY COMBUSTION CHAMBER VOLUMETRIC GUIDELINES

WASTE TYPES	CUBIC-FEET OF PRIMARY VOLUME PER POUND OF WASTE	
	Heat Release Rates per Hour	
	15,000 Btu	25,000 Btu
Type 0	0.56	0.34
Type 1	0.43	0.26
Type 2	0.30	0.17
Type 3 & 4 with Auxiliary Fuel	0.26	0.16
Solvents (@ 15,000 Btu/lb)	1.0	1.7

TABLE 5

PRIMARY COMBUSTION CHAMBER HEARTH BURNING RATE GUIDELINES(1)

WAITE TYPES	MAXIMUM BURNING RATE IN LB/SQ-FT/HR OF VARIOUS WASTES						
	CAPACITIES IN LB/HR						
	100	300	500	800	1000	1500	2000
Type 0(2)	26	32	35	38	39	41	43
Type 1(2)	26	32	35	38	39	41	43
Type 2	20	25	27	29	30	32	33
Type 3	16	20	22	23	24	25	26
Type 4(3)	10	14	16	18	--	--	--

(1) Reference Incinerator Institute of America Incinerator Standards, Page 6A

(2) Burning rate affected if waste contains more than 10% dense materials such as computer printouts, magazines, catalogs or packaged papers

(3) Maximum burning rate is a function of the largest animal. If largest animal exceeds 1/3 hourly incinerator capacity, use rating of 10 lb/sq-ft/hr

TABLE 6

SECONDARY COMBUSTION CHAMBER VOLUMETRIC GUIDELINES

WASTE TYPES	CUBIC-FEET OF SECONDARY VOLUME (1) PER POUND OF WASTE PER SECOND OF FLUE GAS RETENTION TIME
Type 0	0.20
Type 1	0.18
Type 2	0.12
Type 3 with Auxiliary Fuel	0.09
Type 4 with Auxiliary Fuel	0.07
Solvents (2) (@15,000 Btu/lb)	0.30

(1) Approximate volumes based upon an assumed operating temperature of 1500°F with 150% excess air

(2) Approximate volume based upon burning solvents alone at 2000°F with 50% excess air

GENERAL OUTLINE SPECIFICATION AND CHECKLIST FOR INCINERATION SYSTEM WITH HEAT RECOVERY

I. GENERAL CONDITIONS AND REQUIREMENTS

A. Scope of Work

All items, equipment and services to be provided by the incinerator contractor. Include specific responsibilities ranging from delivery of equipment through final acceptance.

B. Codes, Regulations and Standards

Technical standards and guidelines, as well as local, State and Federal regulations dealing with incineration, air pollution control and hazardous waste disposal.

C. Submittals

Requirements for submission and approval of shop drawings, catalog cuts, calculations, loading diagrams, performance data, test reports and as-built drawings and wiring diagrams.

D. Performance Requirements

Levels of performance to be guaranteed and demonstrated by testing for:

1. Stack emissions
2. Hourly burning rate, or capacity, for specific wastes
3. Burnout, or degree of waste destruction
4. Auxiliary fuel usage
5. Waste heat recovery
6. Hazardous waste destruction efficiency, per specific regulations

II. WASTE DATA

A. Compositional weight fractions: average and ranges

B. Physical parameters: average and ranges

C. Chemical and thermochemical data:

1. Heating values (Btu/lb)
2. Moisture
3. Ash
4. Hazardous constituents per specific hazardous waste regulations

III. EQUIPMENT AND MATERIALS

A. Incinerator

1. Type and basic description
2. Operating cycle
3. Primary chamber criteria
4. Secondary chamber criteria
5. Construction criteria:
    - Refractory and insulation
    - Design skin heat transfer

B. Solid Waste Loader System

1. Type, description and loading method
2. Basic components: loading hopper, hopper cover, ram, incinerator fire door, fire door shroud, hydraulic system, controls and panel
3. Additional components and features: temperature interlocks, hopper fire detection and protection system, cycle timers and emergency override, hopper loading skirts for spill prevention

C. Ash Removal System

1. Type and description: manual, semi-automatic cart type system or fully-automatic conveyor type system
2. Semi-automatic system components: primary chamber ash transfer/ejection system, ash discharge seal gate, air-tight ash cart enclosure, ash carts, ash cart removal and dumping system, dust supression spray system, incinerator interlocks, safeties and controls
3. Fully-automatic system components: primary chamber ash transfer/ejection system, ash discharge chute, full-submersion water quench trough, heavy-duty drag or flight type conveyor system, conveyor discharge shroud or hood, incinerator interlocks, safeties and controls

D. Combustion Air System

1. Primary and secondary chamber air supply criteria

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2. Control and modulation basis

3. Components: blowers, ductwork, dampers and controllers

E. Auxiliary Fuel System

1. Fuel: natural gas, distillate fuel oil or combination gas and oil

2. Primary and secondary burners: number, location, design ratings (BTUH) and type

3. Burner control basis

4. Burner components

5. Piping trains and accessories

F. Waste Heat Boiler System

1. Boiler type

2. Boiler rating and design criteria:

   - Steam flow rate or boiler horsepower
   - Design working pressure and operating pressure
   - Flue gas pressure drop
   - Inlet and outlet temperatures

3. Boiler trim and accessories: safety valves, low water cutouts, high pressure limit switches, water column, blowdown valves, steam non-return and check valve, feedwater stop/check valve or modulating valve, control and alarm panel

4. Insulation and jacketing

5. Optional accessories: soot blowers and supplemental fuel firing

6. Feedwater system:

   - Condensate tank and/or deaerator system
   - Feedwater pump set
   - Chemical treatment system
   - Water softening system

G. Chemical Solvent Burning System

1. Type: liquid injection nozzle, dedicated solvent burner or combination auxiliary fuel/solvent burner

2. Unloading, storage and handling system:

   - Storage tank: capacity, construction and accessories; agitation, level indication, overfill protection
   - Fill station
   - Container and vial crushing and separation
   - Tank enclosure room
   - Transfer and burner feed pumps
   - Controls, safeties and alarms

3. Special regulatory requirements for hazardous waste treatment, storage and disposal facilities

H. Air Pollution Control System (If Applicable)

1. Type: baghouse filter, wet scrubber, wet electrostatic precipitator, other

2. Inlet flue gas conditions: ACFM, temperature, moisture, dry gas constituents

3. Inlet contaminants:

   - Particulates: mass emission rate, particle size distribution and cut size
   - Acid gases

4. Removal rates or efficiencies

I. Induced Draft Fan

1. Type and construction

2. Rating: CFM, static pressure, operating temperature, maximum RPM, noise level and cumulative safety factors

3. Drive: direct, V-belt or timing belt

4. Mounting and balancing

J. Draft Control Damper

1. Type and construction: multi-blade or vortex

2. Control system

3. Location

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K. Boiler By-Pass System

1. Type: dump stack with lid or by-pass breeching with isolation damper
2. Control and actuation system
3. Construction

L. Breeching System (s)

1. Type and construction:
   - High Temperature: between incinerator and boiler or air pollution control system and as by-pass directly to stack
   - Low Temperature: outlet of waste heat boiler and air pollution control system
2. Internal dimensions or maximum flue gas velocities
3. Accessories: equipment connections, expansion joints, access doors and supports

M. Stack

1. Type and construction
2. Dimensions: height and internal dimensions or maximum flue gas velocities
3. Support system: base supported, intermediate floor level supported, with or without guys
4. Design wind loading
5. Accessories: stack screen, breeching connections, test ports, access ladder with safety cage, drain, lightening and grounding protection systems, thimbles and flashing

N. Tools

1. Normal, daily firing and operating tools
2. Special tools for adjustments and calibrations

O. Spare Parts

1. Replacement parts for first year
2. Parts for beyond first year

P. System Controls and Instrumentation

1. Main panel:
   - NEMA type and construction features
   - Connections, arrangements and mountings
   - Systems, components and items to be wired
   - Status indicating and alarm lights
   - Annunciation panel
   - Monitoring and recording instruments: temperatures, pressures and flows
   - Switches
2. Operating sequences:
   - Normal system startup
   - Normal running control
   - Normal system shutdown
   - Safety and emergency controls, safeties and shutdown

IV. INSTALLATION, STARTUP AND TESTING

A. Installation and Startup Requirements

1. Specific responsibilities
   - Furnish equipment and materials
   - Furnish and provide erection supervision
   - Furnish and install
2. Field engineer or erection supervisor
   - Qualifications
   - Responsibilities
   - Availability
   - Sign-off

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B. Performance Testing

1. Procedures, requirements and responsibilities: operational, performance and emissions testing

2. Test laboratory quality

3. Test report submission requirements

4. Retesting and corrective measures upon test failures

C. Operating Instructions

1. Operator training

   - Duration and scheduling

   - Instructor competency

   - Acceptance

2. O&M Manuals

   - Specific contents, format and requirements

   - Quantities, schedule and revision requirements

V. OTHER APPLICABLE SECTIONS

A. Demolition and Removal (if replacement or upgrading)

1. Reusable components

2. Periodic and final cleanup

B. Miscellaneous Metal and Equipment Supports and Framing

C. Painting - Shop and Field

D. Piping, Valves, Fittings and Accessories

1. Services: auxiliary fuel, fresh water, steam, condensate, feedwater, chemical feed, vacuum, hydraulic, pneumatic, chemical solvents, scrubber piping, drains

2. Materials, installation, testing and workmanship

E. HVAC for Incineration/Heat Recovery Room

F. Electrical

1. Services: power and controls

2. Wiring, raceways and conduit

3. Motors and motor controllers

4. Installation and workmanship

Computerized Planned Maintenance

Richard S. Jacobs
Mary Jo Lewis

Physical Plant Department
Washington State University

ABSTRACT

The computerized planned maintenance system uniquely integrates functions of scheduling, time reporting, project management, stores inventory and billing.

The on-line database system records maintenance history for each equipment item in four cost categories: preventive maintenance, repairs and call backs, materials, and subcontracting. Maintenance history is kept by type of maintenance for labor hours, labor costs, the number of services performed and materials used.

A unique system feature affords flexibility to adjust the workload to available staff. Services are based on equipment use as well as calendar date inspection and service. A schedule is produced from which the maintenance due is scheduled or deferred.

Maintenance workers are given time sheets with detailed maintenance instructions for each assignment. Labor and material costs are posted to the item record and maintenance projects simultaneously. Current maintenance status is immediately available through a computer terminal.

Monthly and annual reports provide summary information. With this information management can plan effectively and define staff requirements based on objectives. Maintenance and deferred maintenance statistics justify budget requirements and aid in selection of areas for budget increase or reduction.

The planned maintenance system has reduced repair costs and assures management maintenance schedules are being met. An exceptions report is produced which informs managers of overdue and deferred maintenance.

The planned maintenance system, integrated with the project management system and inventory management system will include all Physical Plant services. Expansion capabilities are provided for structural, custodial and vehicle maintenance.

A paper presented at the 1984 APPA 71st Annual Meeting, June 17-20, 1984, Columbus, Ohio.

Introduction

The Physical Plant Department at Washington State University, Pullman, maintains facilities, grounds and motorized equipment for a large institution in a rural community. Washington State University is a complex organization with 9 colleges and 90 academic and administrative departments. WSU is not unlike other teaching and research institutions in the facilities provided in fulfilling its mission. The Physical Plant Department maintenance budget is 7.3 million annually at the current funding level.

In late 1979 Washington State University began a program to update facilities maintenance. Priority was given to mechanical/electrical equipment. Prior to 1980 the University did not have a complete inventory of fixed equipment or other capital assets in any useable form for identifying the maintenance services that should be accomplished. Regular scheduled maintenance was impossible because the equipment was not identified. Equipment was receiving some routine service, but mostly maintenance was done on a breakdown or failure basis, or when a potential problem was otherwise discovered. The maintenance staff was either very busy or faced with idle time. Building occupants complaints and requests comprised the majority of service order work on a daily basis. When routine maintenance was performed, there was no way to assure the same work was done on each piece of equipment for the same problem or service. Management and craft supervisors did not have the ability to coordinate parts requirements. As a result there were frequent service delays. Although repair and emergency service costs were high, Physical Plant management lacked the information to analyze the source of the cost. Maintenance budget requests to correct the situation were difficult to justify.

As a result of this dilemma, the Physical Plant Department and the University Administration, recognizing the long term necessity for adequate equipment maintenance, approved the computerized planned maintenance development project. In early 1980 WSU commenced an effort to inventory the equipment in 120 buildings. While the extensive equipment inventory was being compiled and entered into the database, the computer system development effort began in earnest. Because the scope of the system would require large data storage and CPU capacity, the decision was made to use the University's large central main frame, an Amdahl 470/v8. In addition the Physical Plant Department system development would contribute to the central administration goal of creating a University central database system available to all administrative users of computing. Physical Plant Management staff and Systems Analysts/Programmers from University Computing Services, responsible for central database development, were assigned to design and development of the system. The overall strategy was to provide an on-line database management system that would integrate all computing needs and recordkeeping requirements of the Physical Plant Department.

SYSTEM DEVELOPMENT

The planned maintenance system was designed to integrate the functions of scheduling, time reporting, project management, stores inventory and billing. Figure 1 depicts the database files and their basic functions that were developed or adapted for use. A diagram of system relationships is shown on Figure 2.

Administrative Database Files

1. Planned Maintenance Equipment File
    - A. Equipment inventory record
    - B. Equipment maintenance cost center data

2. Maintenance Assignment File
    - A. Instruction set text
    - B. Maintenance assignment data
        1. To-be-scheduled dates
        2. Shop (area) assignments
        3. Task Times

3. Stores Supplies File

4. Project Management File
    - A. Facilities cost centers
    - B. Recharge cost centers

5. Facilities Space Inventory File
    - A. Building, room identifications
    - B. Space use data

6. Employee (job) File
    - A. Employee identification
    - B. Labor charge rates

7. Requisition File
    - A. Billing information
    - B. Charge out documents

Figure 1.

All equipment inventoried would be entered into the Planned Maintenance Equipment File. The location of all equipment would be edited against the University's facilities space inventory. In other words, only locations defined in the central data base were used on the equipment records. The Facilities File identifies all building areas by number and provides pertinent information on these space definitions. All equipment, therefore, could be readily located. The space information required had been previously developed, which was a significant advantage in the design effort.

Equipment Inventory and Classification Before inventory could actually begin, a numbering scheme had to be developed. The fixed equipment to be inventoried had to be identified and classified. A numbering scheme which would eliminate reporting errors was imperative to insure the integrity of the labor and the material costs being reported. The equipment classifications are assigned for generic compatibility with the database Stores Supplies File, as well as their need for maintenance.

The numbering scheme selected would serve only two purposes: (1) the number would be unique and (2) provide the capability to edit for reporting

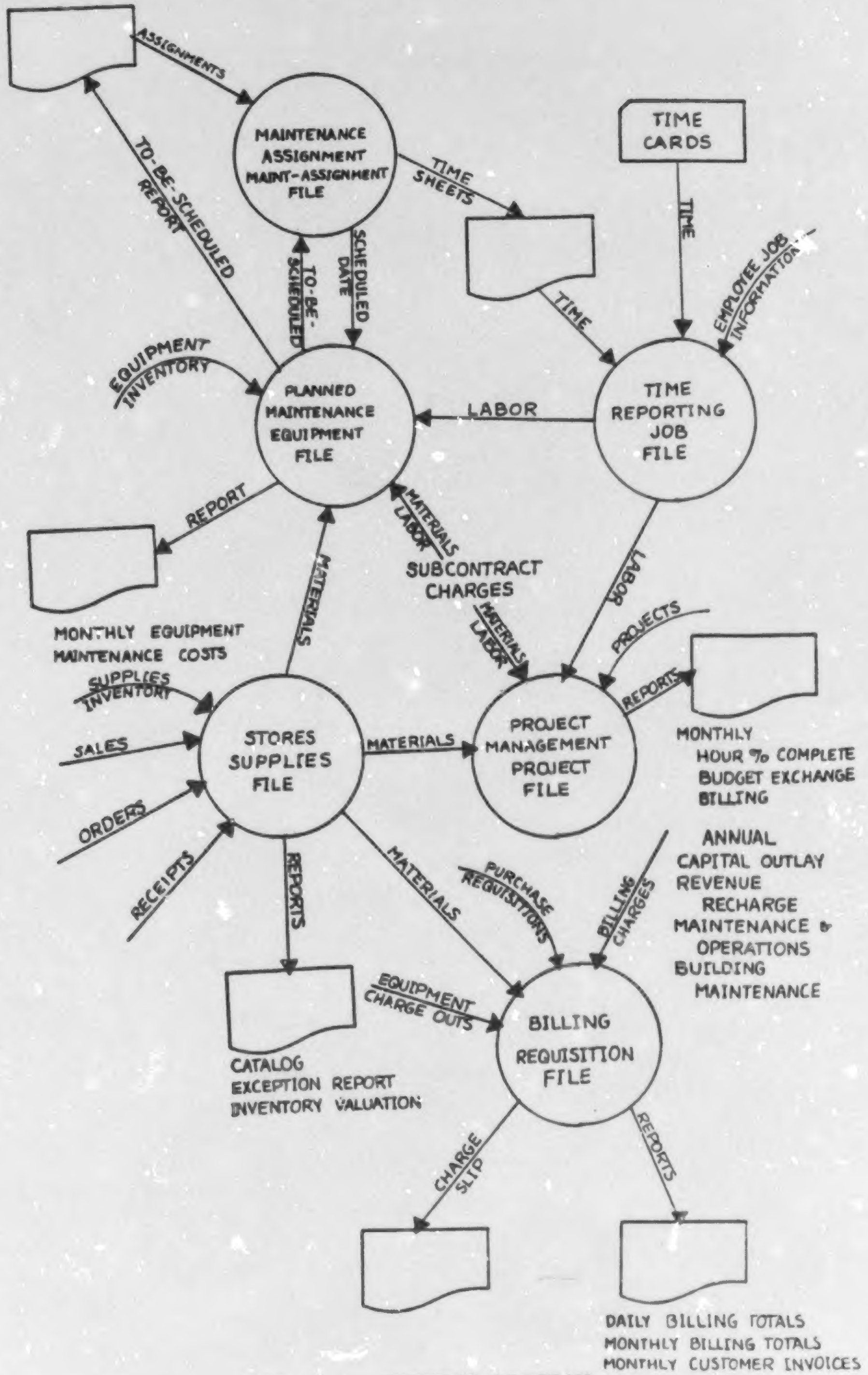


FIGURE 2. SYSTEMS DIAGRAM

errors at data entry. A group of 75,000 6-digit numbers were printed on Mylar labels with the sixth digit being a "mod 7" check digit. The numbers are automatically posted on the project and equipment records for scheduled PM services. This is not the case for stores purchases against equipment or for non-scheduled repairs and call-ins. The check digit numbers are automatically edited at data entry for transposition errors or simple writing and key punch mistakes. The number of misapplied postings is kept minimal and data integrity is assured.

The classifications were assigned item numbers which would exist in both the Stores Supplies File and the Planned Maintenance Equipment File. A list of the equipment inventory classifications is shown on Figure 3.

The equipment on Figure 3 is of two types. These are hosts or components. Some types could be either a host or a component of a host. An example of an equipment item that would be a host or a component would be a control valve. A control valve could receive service as a host unit in certain applications or receive service as a component of a thermostat in a temperature control unit or system.

Two additional digits were added to the six digit inventory number to identify hosts and components in the data base. An eight digit number with zeros on the end (i.e., 12345600) would represent a host equipment item and is an equipment cost center. All other eight digit numbers in the equipment file are components of host cost centers.

It took nearly a year for a crew of 7 people to inventory the equipment in 120 buildings. Approximately 75,000 items were inventoried. Of these 30,000 were entered into the equipment database as host items or equipment cost centers. The remainder were entered as components for performance tracking and parts requirements.

Several types of equipment were inventoried individually but are inspected and serviced as a group. Door locksets and emergency eye wash units are examples of the equipment that are readily grouped for maintenance. On a regular scheduled interval all the door locksets in the building are inspected for problems on one service order yet they are individually inventoried for purposes of keying schedules, service call verifications and other informational purposes.

Each equipment record to which maintenance costs are posted contains a project number, the scheduled maintenance services and maintenance history from beginning to date. The complete description is provided for parts identification and the location of the equipment.

Maintenance Instructions After the equipment classifications were established and while the inventory was taken, the potential maintenance services were analyzed. Manufacturer's warranty requirements, engineering service recommendations and input of maintenance personnel were used to develop a standard set of instructions for the equipment classifications. Each instruction set in addition to the text of the service contains a maintenance frequency as shown on figure 4, a task time and the craft shop or maintenance supervisory area that will perform the service and planned

EQUIPMENT INVENTORY CLASSIFICATIONS

MAINTAINABLE EQUIPMENT

- Aftercooler
- Air Compressor
- Air Damper
- Air Filter
- Aisle/Stair Light
- Backflow Preventer
- Chiller
- Clock
- Condensate Meter
- Condensate Pump
- Control Valve
- Converter
- Cooling Coil
- Cooling Tower
- Damper Operator
- Deionized Tank Set
- Distribution Panelboard
- Door Closer
- Door Lockset
- Drying Cabinet
- Electric Steam Generator
- Electric Water Cooler
- Emergency Eye Wash
- Emergency Generator
- Evaporative Cooler
- Exhaust Fan
- Exit Device
- Exit/Directional Signs
- Expansion Tank
- Extinguisher System CO_2
- Faucet
- Fire Alarm System
- Fire Curtain
- Fire Extinguisher
- Fire Sprinkler System
- Fire Standpipe
- Fixed Furniture
- Fume Hood
- Furnace
- Gate/Globe Valve
- Halon Fire System
- Heating Coil
- Hose Rack
- Hot Water Heater
- HVAC Mech. Room Unit
- Hydrant (Fire)
- Lab Sink
- Lab Table Outlet
- Lavatory Fixture
- Light Fixture
- Low Pressure Boiler
- Main Distribution Panel
- Motor Control Center
- Pipe Strainer
- Power Transformer
- Primary Switchgear
- Pump
- Purge System
- Quality Control Light
- Receiver-Controller
- Refrigeration Compressor
- Resisivity Monitor
- Safety Shower
- Sash Hardware
- Smoke Hatch
- Steam Reducing Valve
- Sump Pump
- Supply Fan
- Thermal Recovery Unit
- Thermostat
- Urinal
- Water Closet
- Water Softener
- Vacuum Pump

COMPONENTS

- Air Filter Gauge
- Ballast
- Belt
- Bearing
- Chemical Feed Pump
- Chemical Monitor
- Component Fan
- Component Pump
- Compressor
- Condensor
- Control Valve
- Electro-Pneumatic Controller
- Engine
- Evaporation Valve
- Evaporator
- Fan Sheave
- Filter (Air)
- Flame Fail Device
- Float Switch
- Flow Control Valve
- Flush Valve
- Generator
- High Pressure Switch
- Low Pressure Switch
- Mixing Box
- Motor
- Motor Sheave
- Oil Safety Switch
- Pressure Reducing Valve
- Recirculating Pump
- Relief Safety Valve
- Static Pressure Regulator
- Steam Trap
- Transfer Switch
- Unfired Pressure Vessel
- Volume/Control Terminal Unit
- Water Regulating Valve

FIGURE 3. MAINTENANCE CLASSIFICATIONS

maintenance code. Maintenance instructions are assigned to the equipment using the PM code. Each PM code can contain up to 10 individual services. The PM code provides the flexibility to assign instructions to equipment in different combinations. Using different PM codes for the equipment classification allows the maintenance services to be adjusted for seasonal operation, facility use, or basing maintenance on run time or "on command" service. Three hundred and twenty six services have currently been developed for the 156 types of equipment in the original inventory. The online Planned Maintenance System automatically attaches the appropriate services to the equipment record, through the PM code assignment, as the equipment record enters the system. With the equipment record in the system and the maintenance instructions assigned adding the actual service dates would be accomplished separately.

Maintenance Scheduling The maintenance instruction sets were placed in the database in March 1981. The equipment inventory, previously edited for duplicate records and errors, was placed in the database in May of 1981. Online editing and system debugging would continue through the summer and fall.

Physical Plant Management decided to implement computerized-planned maintenance in a cross section of 19 core buildings representing the three major colleges of the institution. The mix included laboratory, classroom and library facilities. The Administration building and the Computer Science building were also included. From the reports now quickly available from the University database it was decided to dedicate a staff of eighteen to computerized planned maintenance.

The buildings selected has 12,000 pieces of maintainable equipment. Although the ability to assign maintenance dates to selected services was available through online teleprocessing it would have taken an inordinate amount of time to assign the dates by online data entry. There was also the problem of adjusting the workload for an unfamiliar and skeptical maintenance staff.

An algorithm was developed by which a first maintenance date was assigned to each maintainable equipment record. A date was assigned to the maintenance service of the least frequency on the equipment record, whether it was a five year or quarterly service. Other more frequent services on the equipment record were projected on the basis of the first date. Since the least frequent service being assigned was five years maintenance task times for all services were projected for a five year period. A five year, 260 week table of the number of assignable staff hours from the maintenance shops (areas) to be committed to planned maintenance was built.

Holidays and the expected nonproductive time (i.e., scheduled breaks, travel, and leave averages) were taken into consideration. Other elements in the table were hours already assigned which would be needed for future assignments, and a date for the week. Dates were assigned to maintenance services when the task time plus hours assigned did not exceed assignable hours. Other services were projected by adding task time of the service to assigned hours. The objective was to avoid overassignment of work which could have resulted in distorted deferred maintenance figures from the outset and an unmanageable work load for the supervisors.

Frequency Hierarchy	Interval Days
5 year	1825
3 year	1095
2 year	730
Annual	365
Semiannual	183
Quarterly	92
Monthly	31
Weekley	7

Frequency Not Subject to Hierarchy	
Startup	365
Shutdown	365
On Command	None

Figure 4. Maintenance Frequency

The service frequency hierarchy shown on Figure 4 provides the least frequent service to include and replace the more frequent services. When the scheduled service labor charges are posted, the date the next maintenance is due are synchronized using the frequency intervals days. Adjustment of the dates avoids having a more frequent service scheduled too soon after a less frequent service. Startup and shutdown services are seasonal and therefore assigned the same date each year. A next service date is never assigned automatically to a on command service. No system is perfect but assigning maintenance scheduled dates automatically using a frequency hierarchy and interval days solves the majority of scheduling problems and alerts management more quickly to problem areas then a manual resetting of dates.

Design Features

Time Reporting With manual record keeping the maintenance staff had reported time daily by hour and half hour increments. The time was posted against a project, work order, or overhead account as regular time or overtime. That was the extent of the labor cost breakdown. As an initial step to introducing the Planned Maintenance System the time card was redesigned. Columns for equipment number, instruction set number, and maintenance type were added. The hour was divided into tenths and the staff encouraged to begin reporting time in fractions of hours. The maintenance staff used the redesigned time card for several months prior to the implementation of the computerized Planned Maintenance System.

The Planned Maintenance System required an equipment number, maintenance type, and instruction set number to be reported. Maintenance types are "M" for scheduled planned maintenance, "R" for scheduled repair or large emergency repair jobs, and "C" for unscheduled service or emergency request that did not involve extensive repair.

An online system for time reporting was developed and pay rates were placed in the employee database keyed by social security number. The hours reported by the employee are converted to cost using the individuals′ pay rate and posted automatically to the equipment and project records.

Project Management The Project Management System developed concurrently with the Planned Maintenance System refined the manual bookkeeping process to account for work units and cost centers. An online system for project management is used for maintenance project tracking. In addition to maintenance projects, the system tracks costs for construction work orders, blanket recharges, and overhead accounts. Costs for facility maintenance as well as equipment service are posted to maintenance projects. The Project Management System is designed to post projects with labor hours and costs from the time reporting system, material costs from the stores inventory system, and subcontract charges from the billing (requisition) file.

Stores Inventory and Billing System The Physical Plant Department has a stores inventory of approximately 12,000 items. The physical inventory of these supplies was placed in the database. Modifications were made to this existing system to accommodate equipment maintenance and other charges required by the planned maintenance system and project management. Subroutines were developed to post equipment records and projects directly as well as access the existing inventory and billing system.

The integration of time reporting, project management, stores inventory and billing gave management and accountants the best of both worlds. A project or cost center accumulated cost at the same time equipment records were being posted. The employee record was updated as posted together with the equipment and project records. The stores inventory was adjusted at the point of sale. The equipment and project records are updated during the same sale transaction. The need for secondary posting was eliminated.

How It Works

Each supervisor receives a weekly report of equipment maintenance due by shop and building. A sample of the report is shown on Figure 5. The To-Be-Scheduled report reflects what is due two weeks in advance. The date period of the report, however, is flexible to management. Maintenance services which have already been scheduled but not completed also appear on the report, showing the date scheduled. The supervisor assigns the work to specific employees taking into consideration the task times. The assignments are entered online at a computer terminal to create the time sheets for the scheduled period. The scheduled service date can be revised until a time sheet is printed. As the time sheet is printed the date the service is scheduled is entered on the equipment record automatically. The specific maintenance instruction for the service is printed along with the time sheet. By the use of available options one instruction set for each service can be printed or one instruction set for several identical services or a group service can be printed. A sample time sheet and maintenance instructions are shown on Figure 6. Time sheets can be printed weekly or daily depending on preference.

The maintenance staff uses the time sheet to locate the equipment and record the time used to perform the service. The inventory number on the time sheet is used to purchase parts from the storeroom for the equipment service. As stated previously, the cost of materials, for either of the three maintenance types is posted directly to the equipment record at the same time the storeroom inventory is updated.

```
Date 11/18/83                 TO-BE-SCHEDULED REPORT  LIFE SAFETY DIVISION       Page 114
                                       WEEK ENDING 12/09/83

LINE      ASSIGN      INVN-NO       ROOM     LOCATION     PM     FREQ    TIME   UNITS     DUE       SCHED

               THOMPSON HALL

                  FIRE ALARM SYS

2323      -----       25530100      0014B                 1       A      3.00            10/21/83 * 11/18/83

                  HOSE RACKS

2324      -----       25536000      0300S                 1       A       .20            12/01/83

2325      -----       25537100      0200S                 1       A       .40     2      12/01/83

2326      -----       25539300      0100      WEST        1       A       .20            12/08/83

                  FIRE SPRINK SYS

2327      -----       25531200      0022A                 1       A     12.00            12/08/83

2328      -----       25532300      0223G                 2       A     14.00            12/08/83

2329      -----       25717600      0422                  2       M       .50            12/08/83

               BRYAN HALL

                  FIRE ALARM SYS

2330      -----       25714300      011B      OUTR WALL   2       A      6.00            11/15/83   11/18/83
```

FIGURE 5. TO-BE-SCHEDULED REPORT

TIME SHEET

11/18/83 D6 1840

LAST NAME FIRST EMPLOYEE NO MO DA YR

HRS	W.O. NO.	EQUIPMENT	TYPE	SET	INC			
----	820747-1	29385600	M	133		REFRG COMPRESSOR	JSN HL	0401
----	820747-1	29390400	M	133		REFRG COMPRESSOR	JSN HL	0352C
----	820747-1	29391500	M	133		REFRG COMPRESSOR AIR COMPRESSOR	JSN HL	0405
----	820747-1	29403000	M	133		REFRG COMPRESSOR COOLER RM 70	JSN HL	B0001
----	820747-1	71165300	M	133		REFRG COMPRESSOR	JSN HL	0170

INSTRUCTION SET

11/18/83 D6 1840

LAST NAME FIRST EMPLOYEE NO MO DA YR

INSTRUCTION SET 133

REFRIGERATION COMPRESSOR.
CHECK OIL LEVEL IN COMPRESSOR THROUGH SIGHT GLASS.
BE SURE IT COVERS HALF OF GLASS WHEN RUNNING.
CHECK OIL PRESSURE IN POSITIVE PRESSURE SYSTEMS.
BE SURE IT READS BETWEEN 50 AND 70 LBS. ABOVE SUCTION PRESSURE.
CHECK FOR PROPER REFRIGERANT FLOW AND MOISTURE.
FLOW SHOULD BE CLEAR WITH NO BUBBLES.
CHECK HIGH AND LOW PRESSURE GAUGES FOR CORRECT READINGS.
REPLACE ANY GAUGES FOUND TO BE DEFECTIVE.
INSPECT ENTIRE SYSTEM FOR UNUSUAL CONDITIONS.

FIGURE 6. TIME SHEET AND INSTRUCTIONS

The data entry staff get the time sheets daily. The time, inventory number, and maintenance service key are entered from the time sheet. Project numbers are preprinted on the time sheet in most instances and need not be entered in order to post a project account. The time reporting system converts the hours reported to cost on the basis of the individual pay rates. Both the hours and the cost for maintaining an equipment cost center are posted directly to the equipment record for the service and the building maintenance project. As the time is posted the maintenance due dates for the posted service automatically advance through the previously described scheduling algorithm.

An exception report provides management with a list of overdue services for a specified time period. When maintenance is overdue management can decide to change the maintenance due date to a different time period or continue to backlog the overdue services. A date slippage program is provided to advance the maintenance due date and reduce the backlog. If the date is advanced the slippage of the date is recorded on the equipment record maintenance history. A deferred maintenance report could be produced from the slippage transaction and the backlog of services.

Monthly reports provide management with the maintenance costs by building and maintenance area (shop). The costs are detailed by regular maintenance, repairs and unplanned service. A multitude of reports can be produced from the information in this integrated system to define staff requirements, provide budget request data or satisfy other management needs for information.

System Benefits

Since the Planned Maintenance System for equipment was implemented the benefits sought have been realized. Physical Plant management and staff have immediate access to pertinent information concerning the equipment description including components and maintenance activity from beginning to date. Discussions regarding replacement or repair of equipment are made easier.

Efficient use of available staff is possible. Supervisors now plan the maintenance workload ahead of time and are reasonably certain of the requirements. Standardized maintenance tasks help the supervisor schedule efficiently. The necessary parts or supplies or equipment service can be purchased ahead of time instead of using valuable labor allocations to make trips back and forth to the storeroom.

The number of emergency repairs has decreased significantly as more equipment is given proper maintenance and previously unknown trouble areas are discovered and corrections made. Cost center and staff projections, normally required during the budget process, are available using the planned maintenance system database files and data elements. Statistical information usually not available by any accurate measure in the past is now easily accessed through a computer terminal.

Future Applications

The computerized Planned Maintenance System at Washington State University is capable of accepting more applications. The system was designed with continuing enhancement and expansion from an established database as a precise objective. Motor Pool vehicle maintenance has been included in the original development project but has not yet been implemented. The vehicle maintenance requirements must be identified before vehicle maintenance is implemented. The capabilities to include structural maintenance, both exterior and interior, are available once an inventory identification of needs is accomplished. A complete facilities maintenance program could be implemented. Planned maintenance of janitorial service and grounds maintenance are feasible future applications.

Budget cuts have resulted in a significant backlog of facilities maintenance. This backlog, resulting mainly from financial constraints, could be entered into the database and maintenance dates assigned. The amount of deferred maintenance or capital renewal objectives, would be defined by default.

The versatility and flexibility of the system have provided physical plant administrators with the tools they have needed for well over a decade. Administrators continue to discover new ways to use and exploit the information provided in the database.

The Authors:

Richard S. Jacobs is the Operations and Systems Development Manager for the Physical Plant Department at Washington State University. As Systems Development Coordinator, Mr. Jacobs has been involved in the analysis, programming and site implementation of the Planned Maintenance and Billing Systems. He continues to oversee the use of these integrated data processing systems at the Physical Plant Department

Mary Jo Lewis is a Systems Analyst/Programmer and group leader with University Computing Services at Washington State University. Ms. Lewis was the project leader of the Planned Maintenance System and the database integration. She continues to coordinate all enhancements and supervises production support of the equipment inventory, project management, supplies and billing systems.

Tuesday, June 19

APPA'84 COLUMBUS, OHIO
CHALLENGES OF PROFESSIONALISM

Misconceptions of Physical Plant Management

By Edwin B. Feldman
Service Engineering Associates, Inc.

There are a number of misconceptions that raise their heads, again and again, in the field of Physical Plant Administration. These mistaken viewpoints prevent the development of optimum departments. Maybe you can use this list for a self-analysis. It is deliberately offered in random order---who knows where you will find your thought for the day...

Misconception

If people look busy, they are doing a good job. Sometimes quite the opposite is true. Some workers are quite skillful in "looking busy" while accomplishing very little. But for some, it is an interesting game to play. Of course, there are a number of people who look busy and are actually doing a good job, but certainly not all.

Misconception

A complaint represents a service failure. It is true that every complaint needs to be investigated, because many of them are valid, and action needs to be taken to prevent their recurring. Further, it is necessary from a public relations standpoint to indicate that your department does respond to these complaints. But the perfect department would probably get some complaints, and it would come from those people who are trying to impress others with their authority, or their bosses' authority; or they have the psychological problem that causing work for others to do makes one feel better.

Misconception

Published time standards provide accurate data. Published time standards must be presented with the assumption that they are for an "average" facility, and that it is maintained under "average" conditions, of which there are many. Most people in service management feel that their facility is perfectly unique, and they are certainly correct in that. Even two identical buildings can be used in different ways. Further, time standards are always based on methods which involve specific equipment and materials; without specifying these things, the standards are too general other than for "ballpark" use. If standards are desired--and they are infinitely better than guesswork--then they should be fitted to the specific facility and its conditions.

Misconception

A termination represents a failure in supervision. In some cases this would be true, of course. But in many cases, it is not. There are some employees who want a "position" rather than a "job". It is simply not fair to the majority of the workers who are effective to burden them with an employee who has no intention of doing a reasonable amount of work. In such cases, a termination would represent a success in supervision, especially in view of the handicaps that one must overcome to accomplish this.

Misconception

The use of a consultant is a sign of weakness. If that were the case, there would be no doctors, lawyers, accountants, presidential advisors, boards of directors, etc. They are all consultants. Very often the opposite can be true, where the use of a consultant indicates the self-confidence necessary to receive recommendations from an objective party.

Misconception

Contract cleaning or maintenance is generally a failure. Many organizations have saved a good deal of money and have received good benefits from these services. Of course, some have not.

Misconception

Contract cleaning or maintenance is generally a success. Just as many people are involved in this misconception as in the previous one! Of course, there are a number of successes, but on the other hand, there are a number of failures where too much money has been paid, too little service has been received, or a combination of these.

Misconception

Everyone wants to be promoted. It is generally true that everybody wants to be in an organization where promotion is possible, but some people, on learning that they were about to be promoted, would quit. Some people don't want to be burdened with responsibility, or simply don't want to make a change. This doesn't mean that we don't want to provide opportunity for those who do!

Misconception

Having no employee turnover is a valuable asset. It can be a considerable handicap--there is no room for advancement for one thing, or for the infusion of "fresh blood" or new ideas. It may also indicate, and this can be most damaging, that effective disciplinary action is not possible because of an over-paternalistic organization. Unfortunately, the Federal government seems to be generally in this condition.

Misconception

If workers ask for help, they have been assigned too much work to do. Workers ask for help for many reasons, and only one of these has to do with assignment. Another is simply a request for attention from the boss. More frequently, this is a smoke screen for the real complaint; the worker has been given more to do than one of the co-workers in the same area.

Misconception

Attendance at a training class should be optional. In our consulting work, we have seen cases where optional attendance resulted in the absence of the very persons who needed the training most. A long employment record does not eliminate the need for continual training for worker and supervisor alike.

Misconception

Fatigue is a sign of excessive work loading. Rather, fatigue (such as perceived by perspiration or shortness of breath) is a natural part of most work. It is very difficult to develop an 8-hour job where fatigue plays no part. The worker complaining of fatigue might be congratulated on getting the work done!

Misconception

A worker promoted to supervisor sees her/himself as a part of management. Would it were in all cases! One of the basic problems of a supervisor promoted from the ranks is that he or she still identifies with the workers. This can be demonstrated by the supervisors saying to the workers, "They have a new rule for us." Much training and counseling is required to overcome this problem.

Misconception

People will do anything to get out of working. As a matter of fact, working is very meaningful to most people, and is very helpful to their sense of well being. Observations of people who have no work to do indicate that they fall apart or get involved in unhappy or unsavory activities. There are untold numbers of people at work every day without being paid for it, which completely refutes the statement.

Misconception

A 3-month probation period is sufficient. Hardly; many workers can mislead their supervisors for a period of 3 months. A 6-month probation period is much more desirable, with evaluations taking place each month, and the most serious evaluation taking place one week before the completion of the 6 months. Actually, a one-year probation would be very desirable. If it cannot be obtained, perhaps an extension of the current probation for a certain percentage of the cases can be arranged.

Misconception

Worker training is not a good investment in a high turnover situation. It may be needed there more than ever! Without training, the high influx of workers will cause considerable damage and perhaps accidents.

Misconception

Setting time standards must involve the use of stop watches. There are many ways to determine or obtain time standards, and stop watches are just one of these. Stop watches are most useful for repetitive short-duration work. For service work, they should not be used at all because of the antagonism they create.

Misconception

People instinctively find the easiest way to do their jobs. What people do is to assume that management has found the best way to get the work done, and what they have been shown is correct. If management shows the incorrect way to do the work, it may then be repeated by a number of workers on countless occasions. Management needs to find optimum work methods, and train people to use them.

Misconception

National averages provide useful staffing figures. They provide nothing of the sort. All that a national average provides is the national average! It may have no relationship whatever to a specific facility. A person with his head in the oven and his feet in the freezer may have an average body temperature.

Misconception

What motivates one employee will motivate another. Since we are individuals, different things appeal to different people. This is why successful motivation requires a "shotgun" effect, of doing many motivational things continually, rather than one or two things periodically.

Misconception

If you give people too much work to do, they will always stay busy. Some people might, but many people would simply give up, asking themselves the question, "Since I can never get my job done, what difference does it make what part of it I get done?" A very negative atmosphere would be created, where the worker would never get a complaint and would never feel good about his performance.

Misconception

Workers should be rotated in their jobs regularly. (See below)

Misconception

Workers should never be rotated in their jobs regularly. Both of these misconceptions are common. Some workers want to be rotated because they get bored, while some want to be rotated because they want to get out of a tough job. Some don't want to be rotated because they feel comfortable in their work, or have developed a good working relationship with their "customers". The rules of rotation are simple: only those workers who want to be rotated will be considered, and then only if their work is satisfactory to their supervisor, and rotation has not taken place within the last 12 months.

Misconception

The severity of discipline should reflect the employee's length of service. That would simply be playing favorites. To give a longer-term employee verbal reprimand, and to give a short-term employee written reprimand for the same rule infraction--although very commonly done--would be unjust treatment.

Misconception

A long-term employee cannot be changed. One may find that older employees are more difficult to change, sometimes, than newer ones but they can be changed. What should not happen is that the supervisor give up.

Misconception

A borderline worker near the end of the probationary period should be given a chance as a permanent worker. Just the opposite! A borderline worker becoming permanent probably will "go downhill". The chances of the worker improving at that point are very slight. The worker should simply be terminated unless it is clear he will make a good permanent employee.

Misconception

Title and pay command sufficient respect and control for the leader; appearances are not important. To be an effective leader, both in the minds of workers and management--and in the leader's own mind--one must look the part. This involves dress, the condition of the office, the clutter on the desk, etc.

Misconception

When a worker is a year or two from retirement, he has earned the right to slow down. This common misconception is in the minds of not only a number of workers, but also of their supervisors, and management as well. This has caused a tremendous amount of difficulty. What the worker has really earned is the right to continue on the payroll if he continues to provide a reasonable day's work--this is simply the employment contract. If the worker fails to perform (and, of course, we are continuing to pay the worker and provide benefits) then he should be disciplined for that failure.

Misconception

More pay means more and better work. The principal benefit of increasing pay is in terms of increased longevity, and also of attracting a better class of employee. But pay in itself does not motivate people to work harder. This has been proven and demonstrated time and time again.

Computerized Maintenance Planning and Estimating System

Dr. Bernard T. Lewis, PE, CPE
Bernard T. Lewis and Associates, Inc.

Introduction

The point must be stressed that maintenance job planning and estimating is not another entirely new program. It is a refinement of one of the basic elements of the Facilities Maintenance Management System -- estimating the job. Let us stand back for a moment and take a look at the overall picture. Sometimes if we look at a master plan in this way, the pieces fall into place better.

Facilities Maintenance Management is simply a procedure for controlling the accomplishment of maintenance work. First the generation or input of work must be controlled. That is, what work shall be accomplished must be decided. Personnel designated as Inspectors uncover the maintenance deficiencies and make recommendations for their correction. Management then exercises its function of work input control by authorizing recommended work or any other work it decides should be done.

Next, work must be controlled during the time it is being accomplished, this is called work in-process control which means control is exerted over the manpower, materials, and money expended on the job. In order to properly control a job, you should know how long it should take to complete it. You must know how many man-hours of work will be required, and how much of what materials will be needed. After the Planner and Estimator (P/E) provides the time requirements, the Scheduler then has the information necessary to schedule the job ahead of time in such a manner that lost or non-productive time is held to a minimum. That is to say, there will be less time waiting for work assignments, materials, equipment, etc., and the trades will be more closely coordinated.

The final phase of this cradle-to-grave control of maintenance work is preparation and review of management reports that show the effectiveness of the entire maintenance management system and provide management with a basis for taking necessary corrective action.

The most important requirement in this system is that of good, sound, accurate estimates of job manpower requirements. Why? Because planning, scheduling, performance reports, and all the rest are only as good as the data available to work with. Job estimates are the foundation blocks of a good Facilities Maintenance Management System.

Work Measurement Systems

Standards in maintenance work measurement can be set in four ways, each of which will assist maintenance management in achieving its goals:

1. Measurement by experience: In practice, each work order is sent to the foreman who is to perform the work. It is his responsibility to determine the scope of work and estimate time for performance based on his personal judgement. As used in some plants, space is provided on the work order form for the foreman to record his job plan. The work order is then routed for necessary approval and scheduling.

2. Measurement by historical records: This method calls for statistical analysis and treatment of historical time data on completed jobs to obtain an average, which is considered a suitable standard.

3. Measurement by work sampling techniques: The productivity of the maintenance worker is measured by using work sampling techniques on a daily basis to obtain the average productivity of the force and the productivity trend. A monthly report is prepared to show the average productivity for maintenance men in each operating department.

4. Measurement by standard time data: This approach relies on the use of basic industrial engineering principles such as time study, work sampling and predetermined time standards to develop elemental standard time data.

At the present time maintenance organizations tend to use one of the first three methods. Experience shows that there are real benefits from using Engineered Performance Standards.

Engineered Performance Standards

A successful manual standard time data system is used by the Naval Facilities Engineering Command, United States Navy, in maintenance work measurement. The data is called Engineered Performance Standards (EPS) and has been published to make it readily available to all maintenance organizations, both public and private.

An EPS suggests the number of hours it takes a qualified worker working under good supervision, exerting normal effort to accomplish a specified amount of industrial engineered derived work.

The printed standards include two key sections. The first section consists of 'spread sheets' which give 'allowed times' for specific jobs. The second section indicates 'task times' or the time it takes for each elemental step listed for jobs in the spread sheets. For the Planner and Estimator (P/E), the key tables are those listed in the spread sheets.

Each spread sheet covers a specific job task area. The spread sheets break the job down into distinct parts. Each part has an allowed craft time range which constitutes an easy-to-use time standard for any necessary maintenance task. The midrange is the recommended EPS time for the job. The lower and upper limits of the ranges given for all of the steps include times for all preceding steps, and times listed for the final parts are total times for an entire job.

Standard allowed times are for portal-to-portal work performed. Craft allowed time should be added to: estimated times for getting to the site, time to prepare for the job, and any other time-consuming activity for the job. Additions might include:

Travel time. Estimated time it will take the maintenance craftsman to travel to and from the site during the job.

Preparation time. Estimated time needed before and after the job is completed. Before the job, it may be necessary to remove obstacles, gather materials and equipment, and perform simple planning. After the job, there may be some cleanup and restoring the site to its original condition.

Delay time. Estimates time for unexpected delays. These may include time lost due to personal problems, delays due to temporary obstacles, delays due to the need for more equipment or materials, or time lost due to other unforeseen causes.

Contingency time. Time it may take to perform parts of a job unforeseen at planning time. Since some planners tend to overestimate contingency time, P/Es should limit it to no more than 10 percent of the job's total estimated cost.

Computerized Planning and Estimating

In addition to the manual application of EPS, a computerized application called 'The Maintenance Job Estimating System' has been developed by Bernard T. Lewis and Associates, Inc. and has the following benefits:

1. Improve P/E productivity through more rapid retrieval of time standards data.

2. Improve craftsman productivity through the greater use of EPS in generating more effective targets.

The P/E performs the following activities:

a. Prepares cost estimates.
b. Visits work sites and classifies work content into job phases which are recorded on Work Order Documents.
c. Prepares detailed resource requirements estimates and records this data on Cost Calculation Summary Sheets.

The Maintenance Job Estimating System is designed to assist the P/E during preparation of the scoping estimate, and during preparation of the detailed resource requirements.

2. Improve shop craftsman productivity through the higher use of EPS in generating cost estimates.

The Maintenance Job Estimating System imposes discipline on the P/E to seek out an appropriate EPS before attempting a non-EPS based estimating technique. Eighty percent of the jobs estimated will contain EPS based data, and eighty percent of the total productive manhours performed will be based on EPS, when the Maintenance Job Estimating System is installed and properly used.

Benefits Calculation (Sample)

CRAFT HRS WORKED/ YEAR	X	NUMBER OF CRAFTSMEN	X	EPS UTILIZATION FACTOR (Manual System)	=	TOTAL APPLICABLE MANHOURS
1,760		210		60%		221,760

CRAFT HRS WORKED/ YEAR	X	NUMBER OF CRAFTSMEN	X	EPS UTILIZATION FACTOR* (Computerized System)	=	TOTAL APPLICABLE MANHRS
1,760		210		80%		295,680

DIFFERENCE IN MANHOURS (Manual vs. Computerized)	X	INCREASED PRODUCTIVITY FACTOR**	=	TOTAL SAVINGS
73,920 Hrs	X	15%	=	11,088 Hrs
11,088 Hrs	X	$11.44/Hour (Craftsmen Rate)	=	$126,847. Actual Dollars Saved Per Year

* Maintenance Job Estimating System of Facilities Maintenance Management System

** Maintenance craftsmen, normally, are 15% more productive when performing under EPS estimated work orders.

Hardware Configuration

The Maintenance Job Estimating System hardware should be configured as follows for a Facilities Maintenance Organization with three Planner and Estimators. There would be one terminal and one printer. One printer is required for each four terminals. One terminal is required for every two to three Planners and Estimators.

Data Input

All data input to the Maintenance Job Estimating System is via CRT keyboard. Data inputs to be used in the System comprise estimating data extracted from the NAVFAC P-700 Series, Engineered Performance Standards, and locally developed performance standards. Additionally used is locally oriented data, such as maintenance crafts average hourly rates, equipment rates, and material costs. These input data are not resident in the System files, but are maintained as separate data files. Output of the System is a cost estimate for a Maintenance Work Order that summarizes the costs of labor, materials, and equipment. See attached Maintenance Job Estimating System (MJE) flow chart for a graphic System description (Figure 1).

System Operations

The System will operate on a microcomputer with an associated printer. The programs are stored on a single diskette. System files are stored on separate diskettes.

System operations are simple to master because they are "interactive" in nature. At every step the computer prompts and guides the user: by listing the functions which can be performed in the form of a "menu"; or by providing a specific direction (e.g., "enter today's date"); or by asking a "yes-no" type of question. At any point in an operation, the user can enter a HELP command and the computer will explain a function and the procedure for its performance. In addition, each Facilities Maintenance organization using the System is provided with a detailed Users Manual, explaining in simple English all aspects of System operation. Finally, user training is available, either on-site or at Bernard T. Lewis & Associates' offices in the Washington, D.C. area.

When the P/E wants to get the best estimate for labor hours necessary to complete a certain job, he will find the estimate by means of this system. It is the responsibility of the P/E to break the job down into phases in which each task is within the same Functional Area. The P/E will be guided through the system by a series of questions to determine values for the individual tasks that he has defined as making up the phase. Output from this system will consist of a collection of Cost Calculation Sheets (see Figure 2) which will be used in subsequent processing by the Maintenance Management system.

This system has been set up so that the P/E will retrieve data from the system in the same way that he retrieves data from the estimating handbooks. Hierarchies (Figure 3) are established and questioning is done to determine the P/E's area of interest.

The designation 'Functional Area' is given to each of the areas used as titles for the EPS handbooks. General Subsets are the Craft breaks within handbooks (Figure 5), main breaks of handbooks with a single craft (example in Figure 4), the subset of locally generated Tasks, or the subset of miscellaneous inserted Task Areas. Specific Subsets (not always necessary) indicate main breaks within a large General Subset (example in Figure 3). (NOTE: Breaks for large groups are made to limit the number of choices presented to a manageable size for display.) The Task Areas are representative of the spread sheets which appear in the handbooks and the Tasks represent the boxes of a spread sheet. This entire process of hierarchies and naming conventions is probably best served by an example (Figure 4). Questioning levels (Task Areas described in a manner suitable for computer application to determine Task and associated Time Standard) have been developed for each of the EPS manuals shown in Figure 5.

A flowchart for operating and maintaining the System is shown in Figure 6.

Summary

A summary of some of the other advantages of MJE follows:

1. The System allows for easy updating of data files.

2. The System provides for automated job tracking. All currently active and completed jobs are displayed in the Job Directory, and those that are completed can be purged to a history file.

3. Great flexibility in the use of local standards is provided. Current Local Standards can be quickly displayed and updated by the System. New Standards area easily added. Furthermore, the descriptions, quantities, and prices of items in these Standards are not dependent upon the material, labor, and equipment files. This allows for custom estimation of the many varied jobs encountered by clients.

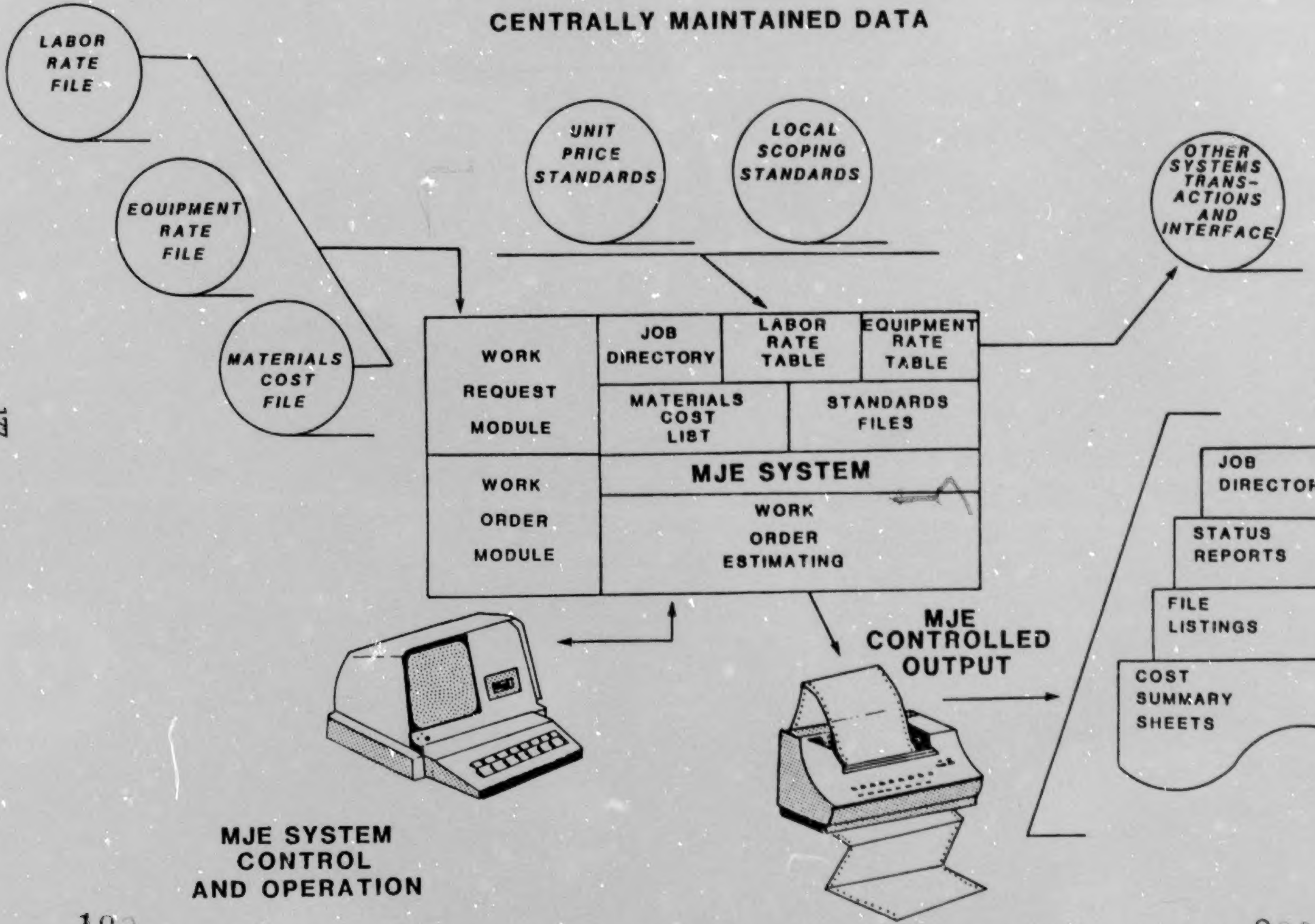
4. Obviously, completely accurate and nearly instantaneous calculations of labor, material, special equipment, and total costs are featured by the computerized System. In addition to the screen display, printed copies of results are readily available.

5. Both EPS and Local Standards are easily attached to jobs. They can be scaled by the work quantity which will result in the recalculation of quantities (labor, material, and special equipment) and new totals will be calculated. Before the Standard is attached to a current job, the capability of modifying prices and quantities is provided.

6. Storage of the Local Standards facilities identification of those that may be later recommended for reclassification to EPS Standards.

Other advantages of MJE will become apparent to the user as he becomes familiar with its use.

MAINTENANCE JOB ESTIMATING SYSTEM (MJE)



CENTRALLY MAINTAINED DATA

LABOR RATE FILE

EQUIPMENT RATE FILE

MATERIALS COST FILE

UNIT PRICE STANDARDS

LOCAL SCOPING STANDARDS

OTHER SYSTEMS TRANS-ACTIONS AND INTERFACE

WORK REQUEST MODULE

JOB DIRECTORY

LABOR RATE TABLE

EQUIPMENT RATE TABLE

MATERIALS COST LIST

STANDARDS FILES

WORK ORDER MODULE

MJE SYSTEM

WORK ORDER ESTIMATING

MJE CONTROLLED OUTPUT

JOB DIRECTORY

STATUS REPORTS

FILE LISTINGS

COST SUMMARY SHEETS

MJE SYSTEM CONTROL AND OPERATION

82-108-3

FIGURE 1

COST CALCULATION SHEET

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***************************************************************************

                                                              DISPLAY 235
WORK CODE NO:  14301     TASK QTY:  100.0    U/M:  SF            REF: EPS
DESCRIPTION:  SHINGLES, ASPHALT, REMOVE AND REPLACE, SMALL REPAIR JOBS.
              (REF:  UT-117)

ITEM NO.      DESCRIPTION-LABOR-MATERIAL-EQUIPMENT     QTY  UI    PPU
1500          ROOFER                                   3.2  HR   14.40
60600         SHINGLE, ASPHALT, 235 LBS., 3 TAB        3.0  BD   10.00
95700         NAIL, ROOFING, 3/4"                      3.0  LB     .11
55600         EAVE STRIP                               4.0  LF     .38


                                                LABOR COST:      46.08
                                             MATERIAL COST:      31.85
                                            EQUIPMENT COST:
                                                TOTAL COST:      77.93

PF1=FIRST      PF2=NEXT    PF3=PREVIOUS   PF4=INSTRUCTIONS  PF10=NEXT UPS
PF11=ATTACH UPS     PF14=PRINT UPS   PF16=RETURN TO UPS TABLE OF CONTENTS

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201

FIGURE 2

HIERARCHIES

Functional Areas

General Subsets of Functional Areas

Specific Subsets of General Subsets

Task Areas of Subsets

Tasks of Task Areas

FIGURE 3

EXAMPLE TO CLARIFY NAMING CONVENTIONS OF HIERARCHY

Electrical Handbook (the Functional Area) may be divided into these categories (the General Subsets):

1. Overhead Electrical Distribution Systems
2. Underground Electrical Distribution Systems
3. Basic Electrical Wiring
4. Preventative and Operational Maintenance
5. Locally Generated Tasks
6. Miscellaneous Inserted Task Areas

of which 1. may be divided this way (the Specific Subsets):

A. Conductors
B. Free Standing Poles
C. Non-Free Standing Poles
D. Wiring
E. Line and Pole Work

of which B. may be divided like this (the Task Areas):

I. Free Standing Poles - Install
II. Free Standing Poles - Remove
III. Free Standing Poles - Remove and Reinstall

of which each of these would be broken into questioning levels to determine correct Task.

NOTE: This is given for example purposes only and does not necessarily represent an actual case. Case in point - An actual case would include 'None Applicable' choices at each level.

FIGURE 4

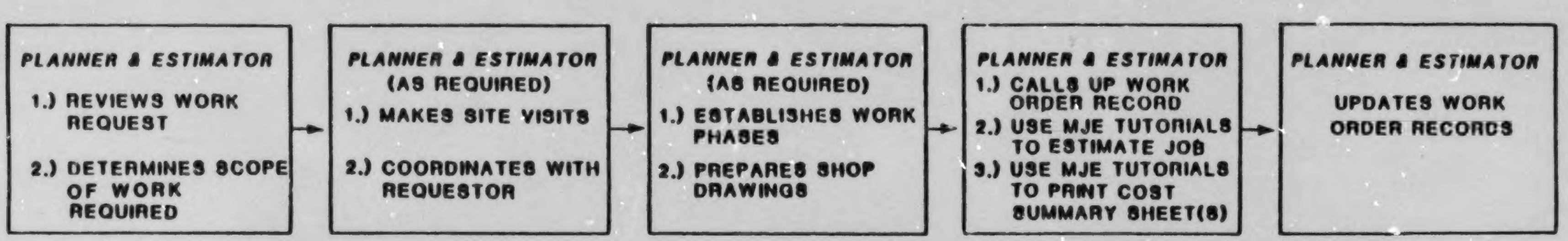
CRAFT BREAKS WITHIN HANDBOOKS AND CRAFT CODES

Functional Area (Handbook - Code and Title)		Craft
02	Carpentry	Carpentry
02	Carpentry	Floor Covering
02	Carpentry	Furniture Repair
02	Carpentry	Glazing
02	Carpentry	Millwork
02	Carpentry	Roofing
03	Electrical	All Subsets
04	Heating, Cooling and Ventilating	Cooling and Ventilating
04	Heating, Cooling and Ventilating	Heating
06	Janitorial	All Subsets
07	Machine Shop/Machine Repair	Machine Shop
07	Machine Shop/Machine Repair	Machine Repair
08	Masonry	Masonry
08	Masonry	Plastering
09	Moving & Rigging	-
10	Paint	All Subsets
11	Pipefitting/Plumbing	All Subsets
12	Roads, Grounds, Pest Control, Refuse Collection	Grounds
12	Roads, Grounds, Pest Control, Refuse Collection	Pest Control
12	Roads, Grounds, Pest Control, Refuse Collection	Refuse Collection
12	Roads, Grounds, Pest Control, Refuse Collection	Roads
13	Sheetmetal, Structural Iron & Welding	Sheetmetal
13	Sheetmetal, Structural Iron & Welding	Structural Iron & Welding
14	Trackage	-
15	Wharfbuilding	-

FIGURE 5

MAINTENANCE JOB ESTIMATING SYSTEM (MJE)

OPERATION



PLANNER & ESTIMATOR

1.) REVIEWS WORK REQUEST

2.) DETERMINES SCOPE OF WORK REQUIRED

PLANNER & ESTIMATOR
(AS REQUIRED)

1.) MAKES SITE VISITS

2.) COORDINATES WITH REQUESTOR

PLANNER & ESTIMATOR
(AS REQUIRED)

1.) ESTABLISHES WORK PHASES

2.) PREPARES SHOP DRAWINGS

PLANNER & ESTIMATOR

1.) CALLS UP WORK ORDER RECORD

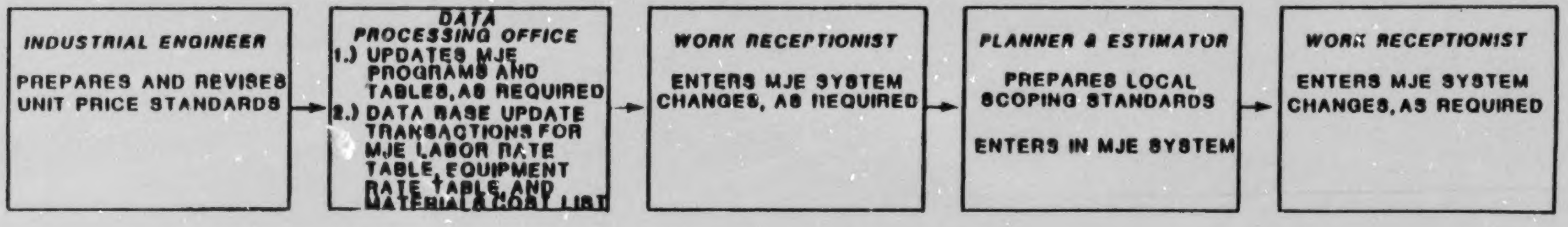
2.) USE MJE TUTORIALS TO ESTIMATE JOB

3.) USE MJE TUTORIALS TO PRINT COST SUMMARY SHEET(S)

PLANNER & ESTIMATOR

UPDATES WORK ORDER RECORDS

MAINTENANCE



INDUSTRIAL ENGINEER

PREPARES AND REVISES UNIT PRICE STANDARDS

DATA PROCESSING OFFICE

1.) UPDATES MJE PROGRAMS AND TABLES, AS REQUIRED

2.) DATA BASE UPDATE TRANSACTIONS FOR MJE LABOR RATE TABLE, EQUIPMENT RATE TABLE, AND MATERIALS COST LIST

WORK RECEPTIONIST

ENTERS MJE SYSTEM CHANGES, AS REQUIRED

PLANNER & ESTIMATOR

PREPARES LOCAL SCOPING STANDARDS

ENTERS IN MJE SYSTEM

WORK RECEPTIONIST

ENTERS MJE SYSTEM CHANGES, AS REQUIRED

FIGURE 6

Detecting Electrical & Building Thermal Envelope Problems

By Dr. H. Z. Lewis, P.E.
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Littleton, Colorado

There is a common misconception that electrical fires result from overloaded circuits or short circuits and that all thermal insulation installations are the same. These ideas suffer from the same overgeneralization as the belief that all water drips coming from above must be roof leaks. In the latter situation, it has been well proven that there are many causes for undesired water entry into a building which do not involve the roof and that a comprehensive testing, inspection, analysis and remedial design program is necessary to properly diagnose and correct the problems. The same is true for electrical systems and building thermal envelope systems. Roof systems have suffered for many years under the burden of neglect due to the belief that they need no maintenance for the magic twenty years. We now know that different components of a roof age and tend to fail at different rates along with there being certain accelerating factors such as ponding water. The same is true for electrical systems although the thermal insulation system, if designed and installed properly, should be effective for the life of the building, provided that it is kept dry.

These are interesting analogies and generalities; what are the specifics? Since electrical and thermal insulation systems are very different, they will be considered separately except for the discussion of the thermal imaging testing concept which is common to both.

There is one design concept which evolved from roofing system design which is common to all three systems and that is the concept of maintainability. There is a difference between buildability and maintainability. The first simply means that the system can be assembled and will function. The second means that after completion, certain components can be accessed for regular inspection and/or removal for normal maintenance. In roofing, this means that a 20 foot square cooling tower mounted 18 inches above the roof renders the roof in that area unmaintainable. In electrical systems, switchgear cannot be installed against a wall unless one wants to de-energize a complete section of the system for maintenance due to lack of rear access. In thermal insulation systems, any portions of the system which may become dislodged, damaged physically or by water, or which may loose thermal effectiveness with time should be accessible. These concepts will be discussed further below.

Electrical systems will be considered first. There are really two factors which must be considered in discussion of electrical system inspection. These are (1) the desire for uninterrupted system operation and (2) safety for personnel using the system. The National Electrical Code has been in effect for many years along with the licensing requirements for electricians who install the systems. These factors have significantly reduced the problems of fire and accidents with electrical systems. However, the rather rapid increase in electrical usage, particularly in older buildings, due to computer terminals, copy machines, greater cooling loads, etc. have placed increased strain on some of these systems. Increased construction costs have caused reductions in safety factors once used and schedules are now tighter which increases the risk of something being installed improperly but not detected.

Newspaper stories abound describing fires reported to be of unknown electrical origin or simply, "a short circuit". Residential fires which often involve improper use of extension cords, failures within appliances or improper use of appliances may fall into these categories. However, in a properly designed commercial - institutional electrical system, a short circuit should never be the cause of a fire unless some safety device does not function. Normally, all electric energy used in a building is transformed into some other form, thermal, mechanical, etc., which often eventually becomes heat. Thus we expect that heat will be created; however, sometimes it is created at places where it is not desired. Consider a simple light bulb circuit. The electric current flows along one conductor to the bulb and returns along the other conductor. The heat generated is defined by the expression, $P=I^2R$. The resistance of the conductors is intentionally made very small compared to that of the load, i.e., the light bulb, so the heat is developed at the load. The load creates a specific normal current, the wires are sized accordingly and an appropriately sized protective device, e.g., a fuse or circuit breaker, is provided to disconnect the power when the current exceeds a safe value. Thus if a short circuit developed between the conductors, the resistance would be very small, a very large current would flow and the fuse would open. The energy which could be developed at the short circuit before power is removed is much too small to start a fire. This assumes that the fuse has not been replaced by a piece of copper pipe. So how do electric fires start?

There is always the possibility of physical damage to the insulation of a cable which would permit current to flow to ground or to another conductor but this does not often occur. The load itself may be at fault, e.g., a lamp ballast may fail or a motor may overheat to the point that its insulation fails. The latter may be due to excessive mechanical load, inadequate ventilation or simply too much start-stop operation. Fires are more likely to start by development of heat at undesired locations. Since the current in the circuit is normally determined by the load, an increase of temperature comes from a localized increase of resistance along the conductors. There are many potential places along a circuit which may develop high resistance such as splices, fuse clips, wire terminations, relay or switch contacts, etc. These may occur due to improper installation, e.g. a screw not tightened. They may also occur quite easily in installations which are completely in compliance with all codes and installation standards which is a factor which is widely overlooked. Due to a variety of environmental influences, oxidation may develop on the conducting medium at the above mentioned potential problem points. The oxide is a poorer conductor than the metal, usually copper or aluminum, which means the resistance is increased and heat develops. The cycle is self-perpetuating because the elevated temperature usually accelerated the development of the oxide which leads to more heat and so on. In high current carrying conductors, only a small increase in resistance is needed to develop significant heating.

What are the consequences of the heat development if left undetected? Over a period of time which may be several years, the temperature can become quite high. Insulation is rated from 75°C up to 90°C for normal applications. Since copper is an excellent conductor of heat, insulation adjacent to the problem may melt away. Terminal blocks may carbonize at elevated temperatures thereby themselves becoming conductive. But most important, the heat will usually eventually cause physical deformation of metal circuit components which will leave a small air gap. Fuse clips can lose their spring clamp capability. The circuit voltage is sufficient to jump this gap and an arc develops. This is the beginning of the end; the arc generates much higher temperatures and it also often causes erosion of material at the gap. All this is happening with normal currents flowing in the circuit so that protective devices cannot detect a problem.

There are several possible scenarios from this point. The arc may damage the device and nearby wire to the point where it must be replaced. The arc may actually lead to a break in the conductor which may permit it to swing free and touch something else. Depending upon the available fault current from the power source, seriously high currents may now flow to ground or another conductor which can generate heat of almost explosive forces if contained. Or the conductor may simply break with no adjacent damage. However, if this circuit serves a three-phase motor, loss of a phase will permit the motor to continue to run if lightly loaded, called single phasing, but it will rapidly overheat; again without tripping any protective devices. The result is usually a ruined motor. With large fused disconnect switches costing several hundred dollars, motor controllers approaching a thousand dollars, and large motors costing several thousand dollars, the direct cost of an electrical failure is significant even if no fire results or no consideration is given to the inconvenience of replacing the device or the possible loss of productivity during the outage. Recalling Murphy's Law and its various correlaries, such an outage will maximize inconvenience. As a possible ultimate example, a bus duct feeding the upper floors of a high rise office building in Little Rock, Arkansas failed on April 8. A major tenant of the affected floors was a large accounting firm whose computers held now inaccessible tax records and whose calculators, typewriters, etc. would not function even for manual preparation of the last minute backlog of tax return preparation. Don't forget the office building somewhere in New York state where a fire involving a transformer with PCB in the oil contaminated the building so that it remains padlocked because the cost of cleanup exceeds the value of the building.

The other aspect of electrical system operation is that of safety for the users as defined by OSHA. While that agency is not a favorite among federal agencies, I must say that their new electrical safety rules which became effective in April 1981 are generally quite reasonable and are intended to avoid unnecessary hazards at the user level. Some members of APPA may not be subject to OSHA regulation but observance of the rules will reduce your liability exposure in any event. There are two classes of rules; namely those which apply to new buildings or major renovations and secondly some specific rules which are retroactive to all buildings because of their more serious potential for employee injury. Examples of the latter are that all circuit disconnect devices must have permanent labels identifying what they control and that all disconnect devices must be readily accessible. The latter means that electrical rooms may not be used for storage which blocks the panels nor may the device be where a ladder is required to reach the device.

Having briefly described the problems, how does one detect them prior to onset of serious damage? Thermal imaging systems permit the presentation in real-time of a heat picture. The devices are very similar to a simple portable tv camera and monitor system except that the camera is sensitive to the infrared wave portion of the spectrum instead of the visible light spectrum. Viewed on a black-and-white tv set, the hot objects appear white, the cold objects black and the temperatures in between as various shades of grey. You may have seen color versions of this where different temperatures are red-yellow-green, etc.; this is not needed nor useful for ordinary inspections. It is important to note that thermal imaging is very different from infrared photography. Infrared film is sensitive only to the portion of the infrared spectrum very near the visible spectrum which comes from very high temperature sources, generally 400°F or greater. Thus IR photos involve reflected light waves from a high temperature source, not the waves which are emitted due to the inherent energy or heat of the object itself.

The thermal imaging systems have special controls which select the span of temperatures between black and white, called Range, and which position the span at a particular place in the temperature scale, called Level. Typical Ranges used for electrical inspection would be the most sensitive, 5-10°C, used for seeking problems on to higher ranges up to 100 to 200°C used for displaying scenes with large temperature differences, normally boiler insulation but occasionally an electrical problem. The Level control positions the thermal range at the desired ambient temperature, e.g. displaying 70-80°F for inside work or 30-40°F for outside work in cold weather. A third control called the Isotherm is used to measure temperature differences in the image; it must be noted that the display is relative, i.e., the Level control is not normally calibrated. The operational sensitivity of the system is typically between 0.2 and 0.5°C which is more than adequate to detect electrical problems long before they become serious. Of greater concern is adequate image resolution to permit distinguishing components in a congested motor control center or inside a switch panel with many cables, bus bars, etc. The resolution of thermal imaging systems ranges from 60-100 lines for lower cost units to 150-200 lines for higher cost units. These are significantly less than the 300-400 lines now available on the better quality broadcast tv monitors. The systems normally can operate continuously for the operator's viewing. When a permanent record is needed when a problem is detected, most units permit the taking of a photograph of the tv image, called a thermogram. So the photos you have seen were not taken with $5 per roll infrared film but came from a $10-30,000 electronic thermal imaging system.

How is an electrical inspection conducted? Traditionally, building owners have turned off their power and had electricians go through the system looking for discolored items and tightening bolts, terminals, etc. Not only is this an inconvenience, it is not likely to find all of the problems. A taped splice at a motor terminal box is not likely to be disassembled just to see if it is ok. A thermal imaging inspection is conducted under normal operational load; the higher, the better. The only inconvenience is that the covers and doors for all panels, breakers, control centers, etc. must be opened or removed to permit direct viewing of the wires and other conductors. Some devices such as fused disconnect switches or bus duct are easy; there are no normal sources of heat to confuse the inspector. However, units such as motor starters or controllers and dry transformers have normal sources of heat such as external overload heaters on breakers, solenoids on relays, small transformers to operate lamps, etc. The operator must know what is normal and how to adjust the camera system to view the portions he must see in spite of the interference of surrounding heat. Heat reflections occur off of shiny surfaces which may appear to be problems but are not. Once a problem is detected, then it is documented with a thermogram and usually a regular color photograph. The temperature rise is measured and the item in trouble is identified. Sometimes current measurements with a clamp-on ammeter are made and sometimes direct temperature measurements using a digital contact thermometer are made. These measurements are important to define whether differences in temperature on different phases are related to an imbalance (not desirable) in phase currents or a problem on the phase itself.

A temperature rise less than 5°C is not usually significant where the cause is explainable. Rises up to 10-15°C are normally developing problems and warrant checking. Rises of 25°C, and particularly over 50°C, warrant immediate attention. Temperature rises grecter than 100°C have been observed. As a reference, most thermoplastic wire insulation is rated at 140°F to 167°F including ambient conditions. The maximum temperature rise permitted at a terminal block is 50°C.

Visual inspection is also important to detect things which thermal imaging cannot see. Occassionally, discoloration will be observed at a problem point which just happens to be cool at the moment. OSHA rules do not permit insertion of multiple small wires into a terminal designed for one large cable. We once found the solenoid which performed the mechanical transfer of contacts in an emergency transfer switch which had its coil melted off. Sometimes maintenance personnel will replace a breaker which trips regularly with the next larger size with no consideration that the wire size does not permit this. We have found fused switches with three different sizes of fuses in the three phases and several instances of copper pipe and bird nests in fuse boxes. Perhaps the most recurring problem is that other personnel do not respect the need for working space around electrical equipment, even to the point of storing flammable material blocking access to major equipment. There are several companies which sell OSHA approved signs of all types which include ones warning not to obstruct access.

Electrical inspections are often combined with some form of inspection of mechanical and steam system components. Bearings on motors, air handlers, etc. are easily checked with the thermal imaging system. Bearing problems can be subtle and the image can help distinguish between a bad bearing itself and one which is being abused due to problems with the belts, e.g. misalignment, excessive tension, etc. Bearings are expensive and the repair of a damaged fan shaft can run up into the thousands of dollars so early detection of problems is desirable. Steam traps which malfunction create two problems, the waste of expensive steam and the mechanical damage of water hammering. A properly functioning steam trap usually has a readily discernible temperature drop from the steam side to the condensate side which the thermal imaging system sees easily. This can also be detected with a digital contact thermometer so less expensive methods are available and are practical. The thermal imaging method has the advantage of "seeing" the entire trap assembly which will permit the detection of a plugged strainer, a trap with no steam passage at all or to check traps overhead not easily reached without a ladder. We usually check all the traps we can during an E/M inspection while we are waiting for someone else to open a box, etc. The location of leaks from, or simply the location of, direct burial steam or hot water heating lines is also a good application for thermal imaging.

Having covered the inspection of existing systems, what about better design of new or renovated E/M systems? Maintainability is the key factor. Access is the most critical problem we face. A prime failure point for racked, plug-in motor control centers is the bus stab. It is necessary to remove the rear panels to view these items and we find many such centers installed backed up against a wall with no rear access. We find conduit routed through covers which need to be removed to see into a large enclosure. We strongly recommend the use of phase loss detectors on circuits serving large motors. Unfortunately building owners regard E/M equipment space as unproductive overhead which should be made as small as possible. Fused disconnect boxes have a provision for bypass of the door interlock, often located on the right side of the box. Often boxes are located so close together it is impossible to get even a stubby screwdriver between them to operate this bypass. Electrical equipment should not be located in areas of high ambient temperature or humidity such as boiler rooms or with interior cooling towers. Steam traps should not discharge into open drains near electrical equipment. Maintenance of motors involves the ability to clean them, change or lubricate bearings, adjust shaft alignment, lift them for replacement, etc.

Continuous duty circuits are segregated for special attention in the NEC due to the above normal temperature rise such circuits often create. Multiple conductors in conduits must be derated. The circuit breakers must be derated. A major problem is that when the use of a space is changed, such as a residence hall is converted to office space, the electrical load is much greater and the use of newer office equipment, even coffee pots, often means continuous loads where the original design did not provide for such use. With some colleges providing personal computers to students, even the normal occupancy load may become excessive.

The provision of emergency on-site generated power is becoming more of a requirement currently. There are several misconceptions here. The first is that the emergency generator will protect against everything.

Not so; it protects only against the loss of commercial power. Beyond its emergency transfer switch (ETS), the power flows through normal electrical switches, etc. and there is no further redundancy. Secondly, the ETS normally serves circuits which are never turned off so how will routine preventative maintenance be performed? There are now associated devices called bypass-isolation switches which remove the ETS from service without disrupting service. These can be physically as large as the ETS itself and often there is now no space in an electrical room for this device. Third, the NEC requires that the generator be tested regularly "under normal load". We have found places where the generator is run regularly but without activating the transfer switch because this fouls up the elevators or sensitive equipment. When needed, the transfer switch would not transfer. Whenever a building needs emergency power, it also needs other accessories to assure it will function as intended. There should be alarms terminated at a full-time attended security station indicating when the generator is running and of any malfunction at the generator such as overheating. These alarm circuits should not rely on normal power for their functioning. If the building involved is located in a freezing weather climate, there should be alarms for the malfunction of any pumps which circulate water where it could freeze should the pumps fail.

The **Professional Pessimist**, what is his function? The inspector should look at a system not by how it works but by how it might fail. This is different from being a nitpicker or a worrywart. It means to evaluate the failure modes, in particular those that might happen together, and then to devise a plan to avoid a disaster. For instance, normally ground fault protectors trip only when a malfunctioning floor polisher, etc. is plugged in and these are readily found and eliminated. But what if such a trip causes the generator to come on but it shuts down due to overheating. Are the circuits in the facility adequately documented such that someone on the night crew could begin isolation of the branches of the system to find the faulty one permitting resetting of the ground fault breaker? Does the electrical room have battery powered lighting so this work could be done in the absence of any regular power? Does the facility's radio system require normal power to function which would prevent its use during such an emergency? How about the telephone system, particularly a new computerized one? In a large electrical system, are there cross feeds between load centers such that one could be fed from another if its normal feed system required maintenance? The Professional Pessimist serves a very necessary function and when these questions are all answered satisfactorily, late night and weekend emergencies will be much less of a crisis.

In large, complicated electrical systems, there are other tests besides thermal imaging which should be made. The main and sub-main protective devices have a complicated coordination pattern to assure that the main breaker will not trip off on a minor branch circuit overload but yet will open quickly on a serious fault. There are current-time delay curves for these devices which are designed to assure their sequential operation which should be tested regularly. Even in smaller systems, the actual tripping calibration of simpler circuit breakers may be considerably in error. This can be helped somewhat by conversion of important units to the use of solid-state sensing which eliminated the thermal and dash-pot devices on older units which need maintenance.

Systems with high feed or distribution voltages should have cable and insulator voltage break-down checked.

We often encounter situations during inspections where the building owner has no idea where all the various pieces of electrical, mechanical and steam equipment which should be tested are located. This is particularly true in hospitals which seem to be continually expanding or renovating and typically have rather complicated systems. One critical piece of documentation which should be kept up to date is the electrical one-line system layout print. A second is an inventory of motors, HVAC units, steam traps, electrical panels, transformers, etc. Both of these deserve the use of a computer for storing and updating the data. There are computed-aided drafting systems which can store the details of system drawings in a manner by which they can be easily changed. These systems are available either through A/E firms or independent computer firms. There are many types of programs appropriate for inventory control, such as the common data base programs available for most micro or personal computers. The programs available range on upward to very sophisticated programs which issue maintenance work orders, both for scheduled preventative maintenance and for requested repairs, and keep a variety of data regarding the costs associated with maintenance of different components of the physical plant. We strongly encourage you to investigate these systems and start using whatever your budget will permit.

As a final comment upon electrical systems, since they are so reliable, they often do not receive the attention they should. Nothing can foul up a good system as quickly as persons from a different trade working around electrical equipment which gets in their way. The best example is what a roofing crew can do to improperly supported conduit running across a roof. The routing of conduit is rarely specified on a project, except for very large pipe. Depending upon which trade reaches an area first, there may be real competition for space between electrical, water, sewer, heating, etc. pipes and ducts. Electrical conduits should always be attached to a permanent structural support, such as a wall or beams and columns. Conduit should never be hung directly from a metal roof deck, only the joists. Conduit on the roof almost always would be better off attached to the outside of the building or routed under the roof. The NEC makes a reference, albeit generalized, to routing of electrical services across roofs in Sections 300-4c and 110-12 which requires adequate permanent support. Placing the conduit directly on the roof membrane is definitely not in compliance with the code. Attaching conduit to the metal coping cover is almost as bad.

Changing topics now to building thermal envelope systems, what are the potential problems and how can thermal imaging help avoid or correct them? When buildings contained little thermal insulation and heating/cooling system were significantly oversized, defects in the design or installation were of little consequence. Now that designers are required by regulation and economics to provide improved energy conservation in building operation, the thermal envelope becomes much more important. The first problem is that the installation of insulation, like the positioning of studs in a wall, is often left to the discretion of the craftsman involved so that designers may have little appreciation of the problems which may be encountered. This normally involves such things as 4 inches of insulation to be placed in a 6 inch curtain wall cavity with no means of support to prevent sagging or the curtain wall is installed flush against the structural columns and beams with no working room for the installer. It is such things as scheduling the installation of sheet metal ducts or plumbing fixtures inside or against an exterior wall before the insulation contractor has a chance to install insulation.

How does one know if a thermal envelope problem exists? In the future, building owners will consider testing of this portion of their building as part of final acceptance. For now, problems usually arise when the energy costs exceed design predictions or when particular parts of a building will not maintain desired interior temperatures during extremes of exterior temperature. There are many factors which can cause the above complaints and one must begin by eliminating those portions of the environmental control system which are not at fault. The thermal envelope is usually the last item considered because it is always assumed to be perfect and it is generally inaccessibly enclosed within walls. While defects in roof systems have been a common complaint in construction for years; a roof no matter how bad can be replaced relatively easily. If the thermal insulation system is not designed and installed properly, correction of the problem will likely involve considerable damage to the building which can be very expensive once the building is occupied. Since there is no second chance, the design must be correct and above all must be idiot resistant to acknowledge and avoid potential workmanship problems.

What causes problems with the thermal envelope? First, there is a fundamental misunderstanding as to what constitutes the thermal envelope. The thermal envelope must completely enclose the building - this seems self-explanatory. What designers forget are the effects of thermal bridges and bypasses. A bridge is a path of high thermal conductivity passing though the envelope. A bypass is where air flow can pass though the insulation layer without actually going completely from inside to outside the envelope which would then be air infiltration or exfiltration. A common example of a thermal bridge is a structural component, usually steel or concrete, which passes through the wall, etc. Columns or cantilever beams supporting an overhang must be insulated over their entirety, either inside or outside the building to avoid being a problem. This is rarely done. Roof decks which extend beyond the building walls rarely have their edges or bottoms insulated but we often find that the space between the deck and the suspended ceiling is used as an HVAC plenum. Uninsulated concrete foundation walls, even below grade, can have significant energy losses. One of the simplest thermal bridges is the common metal window frame. Here there is also a simple solution called a thermal break. This is nothing more than a specially shaped piece of low conductivity plastic fitted between the inner and outer sections of the window frame. Another common thermal bridge problem is a slab on grade at the entrance to a building which is connected directly to the interior structural concrete. Again a thermal break is required but this becomes more complicated when a structural load must be passed through the break material.

Bypasses are usually more subtle. A typical example would be the installation of 9 inch insulation batts between bar joists supported by wires running between the bottom bars of the joists. There is an air space above the insulation between it and the roof deck. There will certainly be gaps between batts at their ends where air can pass through the insulation layer. Similar situations occur in walls or normal ceilings where pipes or lighting fixtures interfere with the easy layout of the batts. Commercial or institutional buildings rarely have the traditional fixed ceiling found in a residence. The metal studs used in commercial construction have several problems which wood does not. The thermal conductivity is much higher. Regular dark stains on a wall are an indication of condensation occurring on the wall due to the metal studs. They are not solid which often permits air movement through the insulation layer. Another problem is that the spacing of individual studs is not defined by the architect but rather is left to the installer. Often doors, windows, piping, etc. force the addition of extra studs which create non-uniform spaces into which the insulation installer must attempt to place the batts. If foil or paper faced batts are used instead of unfaced batts, these often leave void spaces next to the interior surface where air may move, again creating a bypass situation.

Thermal imaging is definitely the testing procedure of choice because the alternative is to tear out walls and ceilings seeking potential problem areas by visual observation. Sometimes a negative answer is useful to show that even though the building has problems, the thermal envelope is not involved. The testing is normally done in cold weather and at night so that there is only one source of heat, inside the building, which is flowing toward the outside. Masonry exterior surfaces create a testing problem for two reasons, (1) they hold the heat from the daytime sun for a long time forcing testing just before dawn and (2) they diffuse the heat which reaches the masonry from the inside making it difficult to identify all but the more serious problems from the outside. Buildings can be inspected from both the inside and the outside. Inside testing is preferable because the pattern (a cold area instead of a warm area) is better defined, provided that the problem can be seen. Obviously, problems with ceilings in buildings with attics must have these areas checked from the inside. Often for large buildings, the initial inspection must be done from the outside first for practical reasons due to the inconvenience of entering each office, removing false ceilings, etc. for inside scanning. Some problems, such as at the band joist or floor beam level or under overhangs, can only be found from the outside. With large buildings, it is normally more convenient to document the inspection proceedings continuously on videotape than to try to take photographs.

Air movement completely through the thermal envelope can also be detected, provided that some suitable means is available during the testing such as by using the HVAC system to develop a positive or negative pressure depending upon whether one is outside or inside. Some of the places where this may occur are relatively obvious and some are subtle. The obvious ones are entry doors without vestibules, inexpensive or poorly installed windows, etc. Completely obvious, but usually overlooked are poorly fitting doors and ductwork seams on HVAC equipment which is installed on the roof. Almost totally overlooked is the leakage of air at the perimeter of the roof via the space between the edge of the roof deck and the parapet wall. The same leakage can occur at curbs for HVAC units and other devices mounted on the roof.

While the title of this paper does not include the inspection and diagnosis of roof system problems because that is a whole subject to itself, one must remember that the roof is a very significant part of the thermal envelope and one which can get into considerable trouble. For a square building with a 15 foot floor to roof height, the wall length need only be 60 feet for the roof area to equal the wall area, i.e., 3600 sq. ft. This is not a large building. For a typical elementary school of about 40,000 sq. ft., the wall area would be 12,000 sq. ft. while the roof area is 40,000 sq. ft. For many years, the only function of the roof was to keep water out of the interior. Now that energy consumption is more of a concern, insulation is being added to all areas of the envelope, the roof included. However, the roof is unique in that its insulation is much more likely to be rendered ineffective due to its becoming wet. Thus roof leaks in addition to being a nuisance and having the potential for damaging the structure by rusting or rotting, may also drive up the energy costs. It is therefore more important than ever to promptly diagnose and eliminate leaks permanently. The concepts of maintainability apply to roofing systems perhaps even more than to electrical systems and to the normal wall insulation.

Another section of the thermal envelope which is often overlooked, particularly when renovating or analyzing energy consumption, is the insulation on HVAC ducts, particularly those exposed to exterior weather. Quite often, these ducts have only 1 inch of insulation with an R-value of perhaps only 2-3. Supply ducts contain air with a greater temperature difference relative to the outside than exists for the basic conditioned space. Therefore, heat transfer will be greater here than via the normal envelope. Since it affects the temperature of the air delivered to the conditioned space, poorly insulated ducts may make balancing of the system difficult in addition to simply raising energy costs. Where supply and return ducts occupy a common space, i.e., supply ducts within a false ceiling plenum space, heat transfer here short circuits the HVAC system again making system balance more difficult while raising operating costs.

The Professional Pessimist is also important in reviewing operation of mechanical and steam systems. Any system which uses water lines which may be exposed to outside air should the overall system fail to function should be identified. Any such water systems should have convenient draining valves along with isolation valves to permit use of parts of the system even though one section has frozen or the pipe is broken. Are there areas which would normally be warm but which might not be during an extended power outage in winter. What about a boiler room with louvers for combustion air which cannot be closed?

There are some fundamental problems with the location of high humidity areas, e.g., pools, saunas, shower rooms, etc. adjacent to exterior walls in regions with cold winters. No matter how well the insulation is supposed to be protected by a vapor retarder (there is no such thing as a vapor barrier), moisture will get through and lead to condensation problems. These areas are better located on the interior of the building where the humidity can disperse into adjacent areas.

How does one find or hire a thermal imaging inspector? While this is somewhat a biased opinion, I feel that an inspector should be as qualified as the original designer which means that the inspection should be conducted under the supervision of a licensed architect or registered engineer, preferably a firm which specializes in testing and remedial design. ASHRAE Standard 101-1981, Application of Infrared Sensing Devices to the Assessment of Building Heat Loss Characteristics, is a general basis for defining the equipment and conditions for the testing. NFPA publication 70B-1983, Recommended Practice for Electrical Equipment Maintenance, is a similar starting point for electrical inspection. No such publication exists for roof moisture testing. The Roofing Industry Educational Institute offers a course on roof inspection and my firm has published a sample roof inspection statement of work. However, no written document can ever define or specify the experience, knowledge or diligence of effort of the most important component of the inspection process; namely the person doing the job.

In conclusion, electrical, mechanical and steam systems need preventative maintenance and thermal imaging is a very cost-effective component of the process of early detection of problems. Other tests are also desirable. Thermal insulation systems normally need no maintenance with the exception of the roof portion where the consideration is the detection of wetness. The key factor is the proper original design and installation. Maintainability is a key element in providing good preventative maintenance of all the systems discussed here.

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"Organizing an Effective Physical Plant Department for the 80s and Beyond"

By Manuel X. Patino
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This paper encourages you to apply a systems' approach, now, as a method for producing effective change in your institution.

While the wording used in the title reads "Organizing..." the fact of the matter is that we all work in existing departments. Therefore, since we must from time to time organize anew, the focus of this paper will be on "Reorganizing...".

When the word "Reorganize" is used it generally connotes position changes such as demotions or terminations. This is too narrow a meaning. Throughout this paper "Reorganize" is used in a much broader context. In the sections that follow examples of "Reorganize" will be shown that range from applying a systems' approach in order to solve problems, to the training that is required to develop problem solvers.

Change

Change can be dangerous if one is not prepared for it or it can present an opportunity for success if one is. It generally comes from outside, not from within the organization. It is never ending and complex.

Figure 1 depicts a model of the dynamics of change with actions occuring in different directions. The Institution, which is the area within the dotted line, has a culture in which the three organizational levels, Administration, Department and Shop, interact. Actions within the institution occur not only in the traditional sense of top down but also bottom up. While these actions may occur in different directions, the specific level's response will depend on its characteristics. In order to effectively reorganize, it is important to understand the characteristics of each level.

Characteristics

The characteristics of any level can be either the building blocks or the road blocks to a successful reorganization. Before one characterizes any level it is essential to differentiate between the Institution's Culture and the characteristics of that level. The Culture of an institution is the manner or style in which it conducts business and produces results. While it may be difficult to differentiate between the Culture of an institution and the characteristics of the Administrative level it must be done. An inability to understand or to come to terms with the characteristics of the administrative level insures conflict regarding any departmental or shop reorganization. No administrative characteristics will be highlighted but the examples given for the department or shop level can be applied to any level.

Characteristicly, at the Department level a Narrow View means that the personnel think only in terms of physical plant. A Broad View means that an understanding of the organization's goals is used to set the direction for the physical plant. When a department incorporates a broad view into its daily routine it logically follows that the services provided should satisfy the organization's needs, whether they are articulated or not. Another aspect that one needs to understand is whether the staff are Actors or Reactors. An Actor is a person who by being prepared for change, decisively acts in response to it. A Reactor is an individual who responds to change by behaving in a nonproductive and chaotic manner.

If the Shop personnel Solve Problems it means that the same problems do not reoccur. If the same problems reappear this indicates that the staff are applying the Quick-Fix. The number of people with the ability to Solve Problems is generally less than the organization's need for this skill. Therefore the number of people with this skill must be increased as one of the goals of any reorganization. Finally the Shop's basic Level of Knowledge must be assessed. If the personnel have a Technical Knowledge then most problems can be solved. However, when the staff has only a Historical Knowledge (i.e. only knows how to fix elements of problems that have been previously experienced) the Quick-Fix is applied.

While the combination of the institution's culture and the level's characteristics may make each institution's approach different there are certain principles that must be present in every reorganization. These principles must be assembled in a cohesive and rational manner. This is embodied in a Systems' Approach.

Systems' Approach

A Systems' Approach incorporates a broad view in applying an Institutionally Correct solution that Solves Problems.

The Systems" Approach implies the simultaneous use of many different types of organized structures in order to solve problems. A system can range from a collection of mechanical or electrical devices to the daily service response provided by a physical plant department.

Unlike the principles in science no universal right or wrong exists for institutional actions since the solutions are culture specific. A solution is Institutionally Correct if it serves the culture, mission, current focus and structure of your institution. The fact that it is correct today doesn't mean it will be correct in the future, since the elements that make a solution institutionally correct change from time to time. In addition there may be several institutionally correct solutions available at any given time. Whichever solution is chosen, it must Solve The Problem. This means that the solution is successful in the day to day work environment. If the solution is effective it is maintained by its own momentum. A good solution is not burdensome or restrictive, but sets a clear direction for action which is allowed and encouraged.

As a starting point, one must define the problem in order to prepare the department for change. Departmental agreement on the nature of the problem is necessary since the solution that is implemented must be supported by them. This support is needed since a successful reorganization can only occur when a cooperative spirit exists.

In order to implement the reorganization, in a self maintaining manner, it is necessary to teach and reinforce the principles of the systems' approach on a daily basis. The lessons must confront real life problems that are people specific and relate to the basic services that are provided. Nothing confuses people more than inconsistency, whether real or perceived. Therefore one must be consistent both in the application and in the principles embodied in a systems' approach. The ultimate success of this process will depend on the ability to develop actors who will cooperatively solve problems in view of a common goal.

To solve the problem one must Address it, Evaluate the departments current Effectiveness in relation to it and implement whatever reorganization is needed to Improve the department's Effectiveness in order to overcome it. The systems' approach described in this paper is being applied at the Physical Plant Department of NYU Medical Center. This case study is applied to develop various solutions to physical plant problems.

Case Study

In this section a systems' approach is applied to solve the problem steming from the impact of the 1975 Oil Embargo on NYU Medical Center. The resulting Energy Management Program was used to begin the reorganization of the Physical Plant Department.

A) Addressing the Problem

Here the approach is divided into four questions. If one steps through and answers the first three questions before acting, the possibility of failure will be significantly minimized.

a) What do we do as a result of REAL CHANGE?

b) How do we implement the solution?

c) How do we maintain the solution?

d) Now what?

a) What do we do as a result of REAL CHANGE?

One may choose to wait and see and then do something or do nothing.

After the Oil Embargo started, the Institution waited six months and concluded that the problem was real and not a market manipulation. It embarked on a program to reduce energy costs since the problem was expected to continue for some time with a significant impact.

b) How do we implement the solution?

In order to do something, the person who is responsible for the effort must be designated. Once the scope has been developed resources must be dedicated in order to achieve results. This is all incorporated into the plan for action that is presented to administration for review, approval and support.

In the case study, the position of Energy Manager was created within the Physical Plant Department. This person's sole responsibility was to develop an Energy Management Program based on payback. The success of the program depended on the ability to develop credibility and trust by implementing low cost, high payback programs and projects. Organizational credibility and trust is crucial for the success of a program since more trust usually brings increased freedom of action while less trust brings the reverse.

The scope of the program included the review and modifications of anything in Plant Operations, Maintenance, New Construction and Renovation. The Energy Management Program started with a study to determine its savings potential, then meters were installed throughout the complex to determine where, how and when energy was consumed. Finally maintenance programs and retrofit projects were implemented. The organizational trust and support was embodied in the directive that was received to implement any project that paid back its investment in one year or less.

c) How do we maintain the solution?

Once the programs and projects are implemented one must achieve the results that were identified in order to secure approval to proceed. Then Feedback is required to ensure the organization's continued support. Information regarding the savings should be provided to all the decision-makers including the physical plant management and shop personnel. Prior to the completion of the implementation phase, training is required to maintain the solution. As a result of this training, problems with the implementation techniques may become visible.

In our case, the resulting feedback system served the Energy Management Program very effectively throughout the Institution. This same effort at the shop level quickly evolved into a broad training program. In the beginning the sole purpose was to inform the mechanics about the retrofit projects. However their technical competence soon became the pivotal element in the department's ability to maintain these "new" systems. The solution required an intensive operational focus that was basic and would develop people who could solve mechanical system problems.

d) Now what?

During the years that a program exists the issue of whether to change its emphasis may or may not occur. The choices can be to maintain it as is, to strengthen, to reduce or to terminate it. As a result of any of these decisions a rebalancing of the department's effort may be required.

Since there was a national energy crises when NYU's Energy Management Program was started, all the resulting activities were highly visible and glamorous. The focus was on implementing new programs and projects. During the maintenance phase a new problem was defined as a result of our inability to maintain the newly implemented mechanical systems. The solution to this "new" problem required a rebalancing of departmental effort since it was necessary to incorporate an intensive operations and maintenance focus into the program. A training system was the solution that would give the appropriate personnel sufficient understanding to solve mechanical systems problems. While the Institution continues to approve the implementation of new projects, both the project and maintenance solutions are integrated early on. Finally the Program's focus has shifted from one of "START UP" to one of Maintenance and Operations.

B) Evaluate Effectiveness

While effectiveness is subjective by nature, as used in this paper it includes the elements of trust, credibility and the ability to produce results while solving problems. This paper does not address the methods one can use to evaluate effectiveness since this is both problem and institution specific.

Irrespective of the method, the evaluation of the department's effectiveness becomes a pivotal element for any reorganization. Both the cause and degree of this effectiveness must be assessed. This evaluation process is not trivial since it requires the correct interpretation of "facts".

The following illustrates how one fact can be caused by different actions. The Control Shop responds to daily service calls regarding environmental complaints such as "too hot" or "too cold". The number of daily calls the Shop receives has decreased. In order to assess effectiveness the question that must be answered is "why the number of calls decreased".

1. Is the staff solving the problems?

2. Is the staff satisfying all the clients by wasting energy?

3. Have the clients given up calling for lack of service?

In fact if energy is being aggressively reduced you may be increasing your daily calls.

Once the evaluation phase is completed the department must improve its effectiveness by any of the following methods which range from feedback to departmental reorganization.

C) Improve Effectiveness

Feedback is a simple method which can be used to enhance departmental credibility and trust. For example, an Information Center can be created in the same location where the service calls are received to alert the clients when a problem occurs (i.e. either a planned or an unexpected down). The affected Department Heads are informed about the nature of the problem, the physical plant's response to it, and its anticipated duration.

One must call clients when service can not be provided within the expected timeframe. Calls are placed to inform them that the expected service will not be provided and they are informed when the service will be provided.

Since effectiveness is also judged on the ability to solve problems one must find out if the client thinks that the problems have been solved. Regularly call, on a random basis, people who put in a service request and ask them if the problem has been solved. This simple feedback will highlight a problem if the complaint still exists. If this technique does not produce the required results it may become necessary to reorganize.

At opportune times one must Reorganize physical plant functions starting at the Department level. The elements that should be in one department are Plant Operations, Maintenance, Construction and Renovations. This is necessary if they are to operate in a complimentary manner with an energy cost avoidance focus. If these elements are not cohesive, conflict can readily result from differing goals. At NYU Medical Center it became necessary to reorganize the Plant Operations and Maintenance functions. This action resulted from the need to improve the Department's ability to solve mechanical systems problems. A Mechanical Systems' Manager position was created with responsibility for the Electrical, Plumbing, Refrigeration, Controls and Plant personnel.

Clarity is also needed in the shops with regards to their functions and responsibility. When different shops have interrelated responsibility for a system, it can quickly become a system for which no one is responsible. An example of this problem concerns the repair of Steam Pressure Reducing Valves (PRV). Our past practices called for the Plumbing Shop to remove and install them, since it was considered a large steam valve. The Control Shop was also responsible since the PRV was activated by pneumatic air and they energized and calibrated it. Finally the Watch Engineers were also involved since they were responsible for the steam system. It was an involved process to coordinate three trades in the removal and installation of a PRV. Our approach was to put the entire responsibility in the Controls Shop.

Many examples of this type exist in any Physical Plant Department. By addressing these problems and reorganizing the shops, albeit slowly, significant improvements in efficiency and effectiveness can be realized.

The concluding element of a department's reorganization concerns Streamlining. The benefits realized from streamlining a department varies significantly from institution to institution, but it can greatly improve a department's effectiveness. If one interprets the scope of Physical Plant only to be Plant Operations, Maintenance and Construction then there may be functions that are contained within Physical Plant which are inappropriate. Some examples of this may be Security, Custodial Services, Parking and Transportation. In an era of increasing complexity the correct balance of physical plant effort may require the relocation of some of these functions.

After the new structure of the department has been determined, one must ensure that the personnel effectively solve problems. The Amount of Time available to address a problem is a critical factor in determining whether the problem is solved or the "quick-fix" is applied. Not all emergencies can be avoided, but the problem that is ignored for a long period of time can become an emergency. One can increase the time available to solve problems by identifying unseen problems before they become emergencies. A technique that can be used to pinpoint problems is based on the ability to see problems in a neighbor's shop rather than in one's own. The information collected concerns any and all nuisance or intermittant problems. When this information is integrated and applied across shops it reduces the number of emergencies and also provides more time to solve problems. Another way to increase the time available for problem solving is to inform the client that the staff is working on it and involve them in the process. Too often, a client becomes impatient when he percieves that nothing is being done.

Once time has been "created", the next ingredient that is needed is a System Focus. This requires that the mechanics understand in total the electrical or mechanical system in question, not just the local device. Without this understanding it is impossible to determine the problem or the solution. Before any solution is implemented ensure that it will not adversely effect the system's performance since this would make it inappropriate. The ability to solve problems requires a blend of common sense and knowledge that is not plentiful in the marketplace. Since the need every institution has for this skill is greater than the supply available, it must be developed through Training.

Before any training technique is applied several essential ingredients must be present for the ultimate success of this effort. The first is that the personnel being trained have the "right attitude". In our case this is exhibited by personnel who take the view that any physical plant problem is their concern, even if they are not assigned to solve that particular problem. Once the personnel have incorporated this attitude into their work habits, credibility and trust must be established between them, their leader and the process. Then the training needed to develop this new cadre of problem solvers, both at the management and mechanic level, can begin. Our training technique requires that the personnel solve real world problems of increasing complexity, which will stretch them but not cause them to fail. Specific problems are assigned to personnel who are required to solve them. During each problem solving phase of this training process one must monitor them to ensure that they do not get themselves or the organization into significant trouble. Prior to implementation one requires the trainee to present the proposed solution for review. This ensures that a proper solution is implemented while critiquing, in a constructive manner, the method used by the trainee to reach this conclusion.

While a training process like this requires a significant amount of effort and patience, it develops a cohesive group of people with a common goal who can solve problems. If one were then to compare the amount of time required to the benefits produced, the payback is overwhelmingly large, and well worth the investment.

In closing, if you take away only two concepts from this paper let them be:

1. Be an Actor not a Reactor!

and

2. Be a Problem Solver!

Dynamics of Change

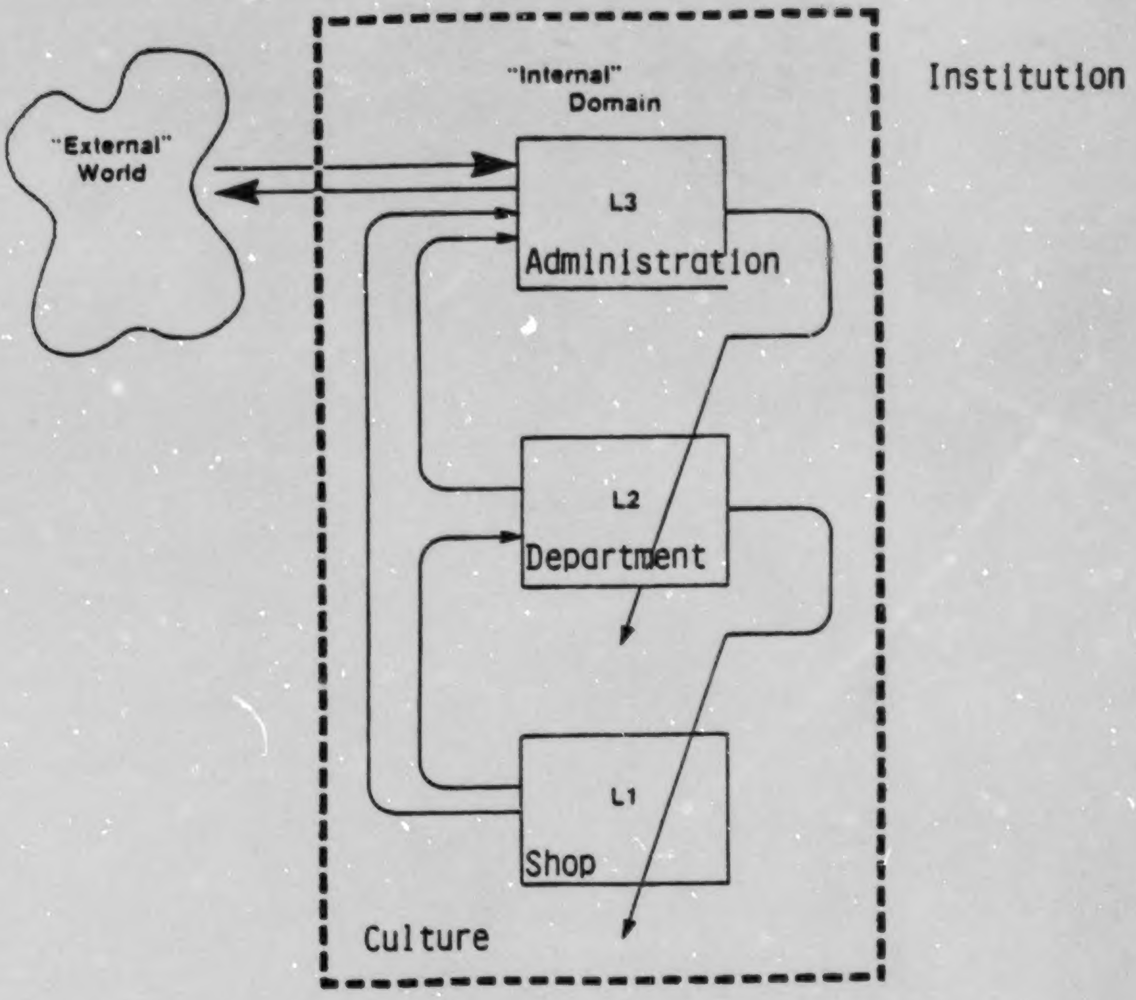

Figure 1

Developing a Professional Policy and Procedure Manual

By William A. Daigneau
University of Northern Colorado

A few years ago, Bob Hunt, then at Loyala Marymont University, delivered a paper at the Phoenix APPA meeting entitled "Your PR-Good, Bad, or Indifferent." At the beginning of the presentation, he quoted a physical plant colleague as saying, "In my opinion, the biggest problem with the physical plants throughout the country today is the lack of credibility." At the time, I wondered if we were actually talking about understanding instead of credibility. I think that most physical plant organizations have a lot of credibility with the people they serve. Most people believe the Physical Plant Department can solve just about any plant-related problem that arises. On the other hand, what these organizations do commonly lack is understanding. Why does it take so long? Why can't I do it myself? Why does it cost so much? Why can't I pick the colors?

Why the lack of understanding? To understand something, people must have information, and to obtain information, you need effective communication. Providing effective communication is probably one of the most difficult components critical to the successful delivery of physical plant services.

How do we communicate to people?

Basically, human beings communicate through two methods--the spoken word and the written word. If we want the people we serve to understand how and why the physical plant organization operates as it does, we must communicate information via one or both of these methods.

Significantly, the effectiveness of the two methods of human communication are not equal. Research on information theory has indicated that:

1. As the complexity of information increases, "understanding"or comprehension decreases much more rapidly with verbal communication than with written communication.

2. People are able to retain complex information much longer when it is read rather than heard.

Now, if we accept the fact that the two methods of communication are not always equally effective, let's examine how your physical plant operation communicates information to your "clients", your faculty, students, and staff.

Think for a moment how you inform them:

-How to obtain keys.
-How to reserve a car from the motor pool.
-What temperature you keep your buildings during winter.
-Why and how much you charge for certain services.
-How to file a complaint.
-Who's responsible for what in your organization.

If you're like many physical plant departments, you use a collection of old memos, word of mouth, or someone elses directive on "how-to-do-it" which is often found in the business office's regulations or a faculty handbook.

If you're one of the lucky few, you have a collection of informal but nonetheless written policies or procedures. If you're a very professional organization, you communicate the how, why, and what of your operation with the help of a formal policy and procedures manual.

Most people shudder when you mention the words Policies and Procedures. I think we all conjure up this vision of a mindless bureaucrat reading to us from "the official manual" on why we can't do something. This has nothing to do with the effectiveness of policy and procedures, but instead on how they are used, or more aptly, misused. More on that later.

Why policies/procedures are necessary.

Why are formal policies and procedures vital to the physical plant operation? There are two basic reasons: First, the very nature of our business is one of complexity. We have an assortment of technical business and regulatory requirements which somehow must all be simultaneously met. For example, not only must we make sure a vehicle is tuned, gased, and ready for use, but we must also ensure that we are able to tell someone how much the trip cost, who took it, for what reason, whether the air pollution controls passed their last inspection, and on and on.

Second, it is not uncommon for the physical plant operation to be the largest single department, employing the greatest number of people, affecting every person on campus, every single day. Why this is important becomes clear when one considers the ancient Latin proverb which says, "A mass of men equals a mass of opinions." To understand how this works, try this experiment. Some winter morning, walk out of your office and announce to your collective supervisory team that effective immediately, no interior space temperature should exceed 65°F. I'll guarantee you that before the day is out, your phone will be ringing off the hook with people attempting to explain to you why your directive can't possibly pertain to them.

So we have two charactistics of our operations; first the complexity of them, and second, the sheer number of people involved or affected by us. That creates a real challenge for effective, reliable, and most importantly, clear communcations.

If we recall our earlier discussion about the advantages of written communication, we can understand why formal written policies and procedures are so vital to a professional physical plant operation. Simply, we need them to consistently explain what, why, and how we do what we do to the people we serve as well as the people who work for us.

Defining our terms

I hope I have convinced you that the professional physical plant organization needs formal, written policies and procedures. If so, our next consideration is how we actually develop a professional looking policy and procedures manual.

With the opportunity of working in both large and small universities, I can tell you that developing your own policies and procedures manual is akin to the old saying about how one goes about eating an elephant. The solution is really one of getting organized and then taking it "one bite at a time." Other than that, the size of your operation and resources have little to do with developing your own manual.

First, we need to clarify our terms. What is a policy and what is a procedure? Generally, we define a policy as the "why or what" of our operations, and a procedure as the "how." If we want to communicate to people "why" we lower building temperatures to 65°F in winter, we would establish a policy on energy conservation. If we want to tell people "how" to get their thermostat fixed, we would develop a procedure on requesting repair services. In some cases, we would want to combine both a policy and a procedure, as in the case of key issuance. Here we want to communicate (1) who can receive keys, (2) what happens when they don't return them, and (3) how to actually obtain or return the keys.

Policies are the principles or rules, and procedures are the methods. The audience for which the policies/procedures are intended may be your own employees, your "clients", or both.

Five steps to your own Policies and Procedures Manual

If you've never had a policies and procedures manual, or if you have one but are frustrated by its lack or organization and its home-grown look, consider the following five steps to a professional manual.

Step I. Organize your manual by defining your organization.

You'd be surprised how often we overlook this important first step. There are several ways of organizing your manual into chapters or sections. It can be organized alphabetically (by policy title), numerically (1 thru 100), or topically. If you're considering alphabetical or numerical, just remember that someday you are going to be leafing through a one or two-inch thick manual trying to find a particular policy or procedure.

I've found that a topical manual is easily organized around your department's organizational chart or classification of accounts. Using APPA's classification of accounts, your manual might have the following section designations and numbering system:

0 - 199	Administration
200 - 299	Building and Equipment Maintenance
300 - 399	Custodial Services
400 - 499	Utilities
500 - 599	Landscape and Ground Maintenance
600 - 699	Major Repairs and Rennovations
700 - 999	Other Services (Security, Safety, Motor Pool, etc.)

For example, if you wrote a policy on the use of sick leave, you would locate it in the Administrative section and assign it a number between 0 and 199, say #101.

Step II. Design a Policy and Procedures form

Good form design and a standardized format will give your policies and procedures manual a polished appearance and lend it credibility. In designing a standard format, you should provide for the following minimum information:

Heading	Purpose
Number	Cross-reference and referral
Date	When established, when last revised
Subject	Title and topical reference
Purpose	Why the policy or procedure was formulated
Scope	To whom or what the policy/procedure applies
Authority	What gives you the authority to issue and enforce
Description	The explanation of the policy/procedure

The Purpose and Authority lines are particularly important. First, if you can't find a logical reason for developing the policy and procedure, maybe you shouldn't be doing it. Completing the Purpose section helps you check that there is a legitimate reason for the policy/procedure. Second, the Authority line helps confirm that you actually have the authority to implement and enforce the policy/procedure. It also helps you gain acceptance of the need for the policy/procedure by demonstrating that you are not just exercising arbitrary management power. For example, you might want to reference OSHA regulations for establishing a policy on the use of safety equipment in your department. Also, note that once you have established a form and format for your policies and procedures, you must doggedly ensure that it is followed.

Step III. Determine and define tha approval process

Before you busily start writing numerous policies and procedures, you should find out who needs to approve them and at what level. For example, a policy on scheduling vacation leave, which applies only to your employees, may require only the department director's approval. But a no-smoking policy, which applies to everyone in the University, may require the President's seal of approval.

So that your efforts are not wasted, early on, you need to find out what level of approval will be necessary for your policies and procedures. This is best accomplished by reviewing the proposed manual with your immediate superior and charting out what approvals may be necessary for different types of policies. As you begin writing your policies, take them one at a time through the suggested approval process. Once you've obtained approval of your first few policies, you'll be surprised how quickly future policies are approved. Also, remember that people are more apt to take action on a single policy issue than a whole book of them. So try to obtain the necessary approvals as you write out individual policies and procedures.

As a side note, don't underestimate the authority that is bestowed upon a policy or procedure when it has been given the seal of approval by someone in the power structure. An employee protesting your department's policy on scheduling vacation leave will often accept it better if you are able to say, "This has been approved by the Personnel Director."

Step IV. Start writing

If you have completed steps I through III, you are now ready to codify your first policy or procedure in writing! One of the best ways to start is to develop a functional description of the entire operation in policy format. Do this by asking each of the major unit supervisors to describe all those functions their particular unit performs. Also, have them identify the major goals of their operation. When they are done, you have a complete description of your entire department. If nothing else, it helps establish areas of responsibility between your own unit managers, and improves intra- department communication. But selfishly, it will also help you delegate responsibilities for writing the policy/procedure manual itself. Whenever an issue develops which requires a written policy, refer to your functional descriptions. Then ask the manager under whose jurisdiction the issue falls to draft a policy or procedure on it. You'll be surprised how fast your manual begins to take shape by distributing the workload. One necessary precaution when delegating responsibility for drafting policies is editing. Each policy should be edited by the director or someone who has a department-wide perspective. This is necessary in order to avoid conflicting policies or procedures which might create headaches for another unit.

Step V. Implement

When you get the organization of your manual completed and some of the major policies or procedures written and approved, it's time to produce and distribute your manual. A master copy of the manual should be kept in the main office. This master should include a complete list of all manuals and of the individuals to whom they were issued. It should also include a numerical order of all policies/procedures and their date of issuance or last revision. Assign to one individual the responsibility of custodian of the master manual to see that all issued copies are kept current.

Distribute your manual to each of your managers and supervisors, your business office, and your immediate superior. Give them a chance to review the manual, then implement. You are now on the road to filling an important void in the professional management of a physical plant operation.

Some helpful hints

The primary obstacle to developing a professional policy and procedures manual is getting organized to do it. There are many "tricks of the trade" that you'll learn as you develop your own manual. However, let me share with you some things we've learned as we developed our manual.

First, keep your policies and procedure simple and straight forward. Everytime you draft one, have your teenage son or daughter read it. If they can't understand it, then no dean or business officer will understand it.

Second, don't try to write a complete manual overnight. It will just frustrate or wear you out. Write policies and procedures as the need develops. The key element to effective communication is quality, not quantity.

Third, be willing and ready to revise a policy or procedure when circumstances show that it has a major flaw, is out-of-date, or has overlooked something important. Remember that policies or procedures are not God-given. They are written by man and they can be changed by man.

Fourth, make sure you hold training sessions with all your employees to review and explain each policy or procedure. The whole purpose was to improve communication--remember? If your people do not understand what a policy or procedure is, or they do not readily refer to them as the need arises, you have accomplished nothing in producing the manual.

Fifth, use common sense in the interpretation and enforcement of your policies and procedures. There is nothing more infuriating than to have a policy forced down your throat without any chance of discussion or appeal. Make sure your managers and office staff understand that policies and procedures are not meant to be blindly followed, but should be used with a good dose of common sense.

Sixth, don't reinvent the wheel. For example, if your personnel department already has a policy on scheduling vacation which meets your needs--use theirs; don't write your own. Likewise, don't be afraid to ask if you can plagerize another University's policy or procedure if it fits your needs.

Seventh, don't worry about creating the perfect policy and procedures manual. "Any plan today is better than the perfect plan tomorrow." Just get started. You'll have plenty of chances to improve it as you go along.

Creating a physical plant handbook or "service bulletins"

One outgrowth of putting your various operating policies and procedures into written form is the relative ease in which they can be condensed into a consumer-oriented handbook. Another option is to develop service bulletins. These can be individual brochures which explain, for example, how one goes about obtaining keys, or reserving a University vehicle, or protecting oneself in case of fire. Usually staff from your publications or public relations office can help you develop an attractive handbook or series of service bulletins based on your written policies and procedures.

Summary

Good communication is vital to the effective delivery of physical plant services. Communications between administrators, supervisors, and employees, as well as with the various members of the University or college community must be clear and concise. Although extremely fast and simple, verbal communications can be easily distorted, particularly when passed from individual to individual. Strict reliance on verbal channels often create confusion, differing expectations, and frustration, within, or directed toward the physical plant operation. In order to reduce this distortion, organizations normally establish formal or informal policies and procedures covering the "who, why, what, and how" of their operations. Unfortunately, although physical plant departments exhibit one of the greatest needs for a written policy and procedures manual, they may be one of the last departments to develop such a manual.

Often the single most significant deterrent to development of a comprehensive policy/procedures manual is getting started! As with other physical plant management issues, the problem of developing clear, concise, written policies/procedures is similar to the old adage of "eating the elephant one bite at a time."

The purpose of this paper was to show how a professional-looking, effective physical plant policies/procedures manual can be developed in-house, without a major committment of either time or of scarce physical plant resources. By methodically following five steps, it is possible to organize, evaluate, and simplify the writing of a manual which includes policies or procedures needed to administer such diverse areas as key control, work request and billing systems, intra-department personnel policies, or regulatory requirements (e.g. no-smoking, hazardous wastes). In addition, the policy/procedures manual can be logically and easily condensed into a series of "service bulletins" for use in a handbook of physical plant services.

Application Of Oxygen Trim Control To Small Packaged Boilers

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Abstract

Small packaged boilers are used to generate steam or hot water for industrial, commercial and institutional power plants. Due to their small size and relatively small fuel capacity, they have not received the energy saving attention that larger industrial boilers have. That situation is changing as energy deregulation brings gas prices into parity with oil.

This paper describes a recent development brought on by these rising fuel costs and the technological breakthrough of low cost microprocessor controls and inexpensive oxygen sensors to measure excess oxygen in the boiler flue gas. The new developments make possible low cost, continuous, automatic optimization of boiler performance by direct control of air/fuel ratio using flue gas analysis trim control.

New mechanical interfaces capable of modifying the relationship between the air and fuel linkage on existing boilers without expensive jackshaft modification or installation difficulties has significantly reduced the installed cost. A field retrofit installation of an advanced microprocessor based system can be installed for under $10,000. This means that users of boilers as small as 150 HP can obtain good return on investment by retrofitting their existing boilers with oxygen trim control.

Typical Packaged Boiler Combustion Control

Most packaged boilers use a simple jackshaft combustion control technique. Steam pressure generated by the boiler is measured by a simple pressure measuring bellows mechanically driving a slide wire.

The slide wire forms one leg of a bridge so that as it varies in resistance, a second variable resistance driven by the jackshaft drive motor moves to balance the bridge.

The jackshaft moves from one extreme to the other as steam pressure varies about ± 5 percent from the normal set point. As can be seen in Figure 1, the jackshaft is simply a steel shaft mounted between bearings across the front of the boiler. Arms connected to the shaft move as it rotates and drives through connecting linkages so as to position the fuel valve and the air damper. Often cams are mechanically inserted in the linkage so that the relationship between air and fuel can be adjusted during installation. If no cams are used, a small amount of adjustment in the linkage angles will provide some characterization between air and fuel.

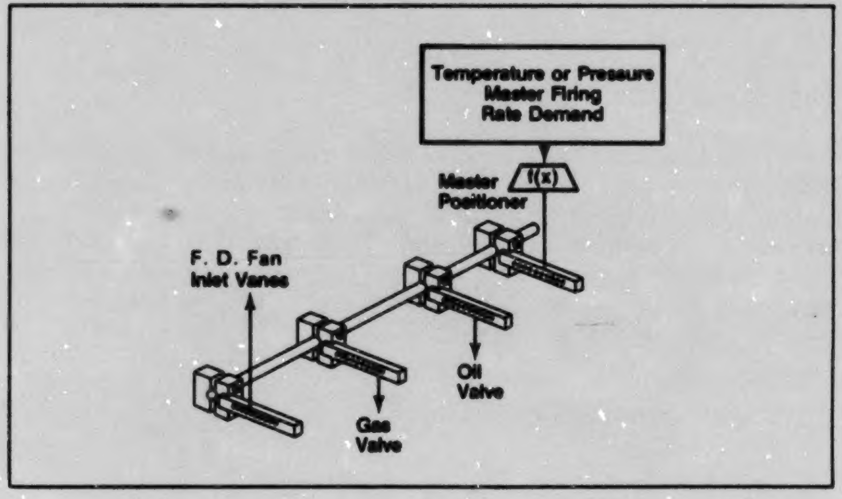

FIGURE 1. JACKSHAFT COMBUSTION CONTROL SYSTEM FOR FIRING OIL OR GAS

Typical Air/Fuel Calibration

Since the air/fuel ratio is obtained via the fixed mechanical relationship between the air damper and the fuel valve positions, small boilers are normally calibrated mechanically to operate with considerable excess air. This procedure ensures sufficient air is present to burn all the fuel under all operating conditions.

Operating conditions vary over time. Thus, the air/fuel ratio obtained will vary widely unless steps are taken to reduce these effects. The main causes for variation include mechanical sloppiness, changes in viscosity, temperature, pressure or calorific value of the incoming fuel, temperature and pressure changes in combustion air, and warm-up effects in the burner and boiler.

It is not uncommon to find the typical small boiler operating with 10 - 15 percent excess oxygen in the flue gas under some operating conditions. This large amount of excess oxygen results in excess stack losses of 5 to 10 percent of the fuel burned.

Stack Losses

Stack losses represent most of the energy wasted in the typical small packaged boiler. Figure 2 illustrates the energy flow in a boiler system. Some losses are not easily reduced without significant system alteration. Stack losses for a given boiler configuration, however, can vary over a wide range depending on the quality of the air/fuel ratio control.

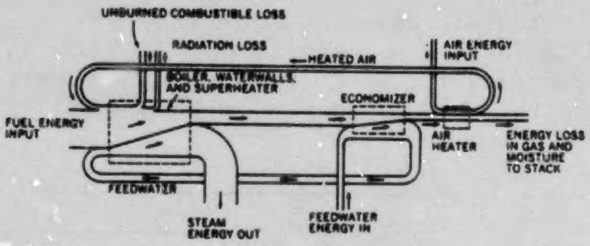

FIGURE 2. BOILER ENERGY FLOW

Figure 3 illustrates the variation in expected furnace losses as the air/fuel ratio varies from fuel rich to air rich. Radiation losces are relatively constant. Unburned combustible losses rise sharply if insufficient air is provided and flue gas losses rise gradually as increased excess air is supplied. The ideal air/fuel ratio produces minimum total losses and is slightly on the excess air side of the chemically correct ratio.

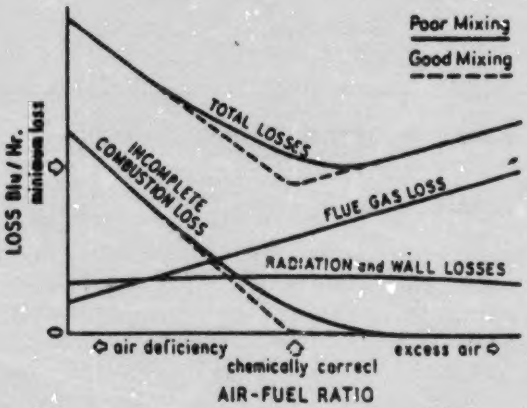

FIGURE 3. VARIATION OF FURNACE LOSSES WITH AIR-FUEL RATIO

Assuming no unburned combustibles, stack losses as a percent of total fuel input can be calculated based on the hydrogen and carbon content of the fuel, the excess oxygen content of the flue gas and the temperature rise from air inlet to stack outlet. This relationship is:

$$(\text{ percent stack loss})_{\text{gross}} = [K_1 \ (\Delta T)/(20.95 - \text{percent}O_{2\ \text{wet}})] + K_2$$

where O_2 is measured as a percent of stack gas including the water vapor formed by the hydrogen in the fuel.

In order to minimize stack losses, Δ T can be reduced by installing additional heat exchangers (air heaters or feed water heaters) and/or reducing excess combustion air. Reducing the excess air, and thus the excess oxygen, has a double payoff. Reductions in excess oxygen increase the denominator and, thus, reduce the stack loss directly. In addition, it reduces the flue gas volume and hence the velocity through the boiler. This reduction provides more time for the heat to be removed, thus decreasing the stack temperature, and hence, the value of Δ T.

Boiler efficiency is related to stack loss by the relationship:

Boiler Efficiency = 100% - (% stack losses) - (% radiation and blowdown losses).

If all losses except stack loss are disregarded, it is common practice to define the remaining value as combustion efficiency.

Combustion Efficiency = 100 - % stack loss.

Figure 4 illustrates the potential savings available by lowering the excess oxygen and/or by lowering the stack temperature. In the figure, select the percent oxygen. Move vertical to the excess air line, then horizontal to the temperature difference line, then vertical to the potential fuel savings axis. In the example shown, excess oxygen is 5 percent and stack temperature is 600°F initially and is reduced to 2 percent oxygen at 500°F. Percent fuel savings is the difference between 2.25 and .75 potential fuel savings or 1.5 percent fuel savings.

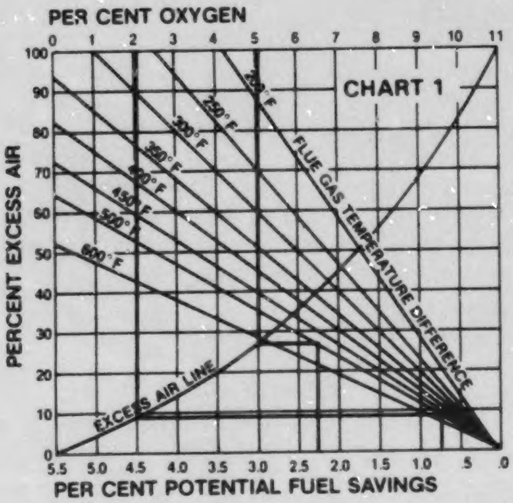

FIGURE 4. POTENTIAL ENERGY SAVINGS FOR VARIOUS VALUES OF EXCESS OXYGEN AND STACK TEMPERATURE.

You can determine the percent fuel savings expected due to equipment or boiler tuning change by selecting the anticipated new values of oxygen and stack temperature.

If you wish to evaluate the change in your fuel bill through excess air control, carry out the following steps.

1. If there are other boilers to take the load swings, place the boiler on manual firing. Operate it at a low load, medium load and high load. Mark the position of the fuel valve and air damper at each load. At each condition, using a portable or temporarily installed oxygen analyzer, a portable CO or combustibles analyzer and a stack temperature measuring bulb or thermocouple, measure oxygen, combustibles and stack temperature. If no other boiler is available to take load swings, try to take the readings when boiler load is relatively steady and catch the load at low, medium and high rates.

2. If the unit is operating with plenty of excess air, as most small boilers without trim control are, there will be very little, if any, CO or combustibles (less than 200 ppm). Excess oxygen will probably vary with load. Higher values will occur at lower loads. It is not uncommon for untuned boilers to have as high as 10 to 15 percent excess oxygen at low loads. Proper, well tuned burners may be operating at 2 or 3 percent oxygen for gas and 3 to 5 percent for oil. If combustibles exceed 200 ppm and oxygen exceeds 5 percent simultaneously, there is a good chance the burner is fouled or not operating properly.

3. With the jackshaft in a fixed position (base loaded), disconnect the air damper and throttle it a little further closed. This new position should reduce the excess air. The excess oxygen flue gas reading should decrease. If CO (or combustibles) rises to between 200 and 500 ppm, do not reduce oxygen further. Note the oxygen value when the CO increase occurs. This rise indicates the lowest excess air condition at this load and provides an oxygen value to compare with the original unthrottled condition. Also note the new stack temperature when this rise occurs. Using the new oxygen content and stack temperature, refer to Figure 4 and compare the potential fuel savings with the original jackshaft condition. Using the available fuel savings percentage at each load, estimate the operating hours for each boiler load and compute the overall anticipated savings.

The Trim Control Jackshaft Interface

An oxygen trim control system applied to a jackshaft type boiler or heater must alter the relationship between the air and fuel valves or dampers if the air-fuel ratio is to be controlled. This alteration has been accomplished in the past by adding a trim actuator that biases or ratios the relative movement of air and fuel arms.

Figure 5 illustrates one approach that has been used. It requires that a new auxiliary jackshaft be mounted somewhere parallel to the original jackshaft and an actuator mechanism M capable of biasing (adding or subtracting an angular rotation) arm B with respect to A or ratioing (adding or subtracting an angle proportional to load) arm B with respect to A. The trim controller then drives the mechanism M to obtain the desired A/F ratio.

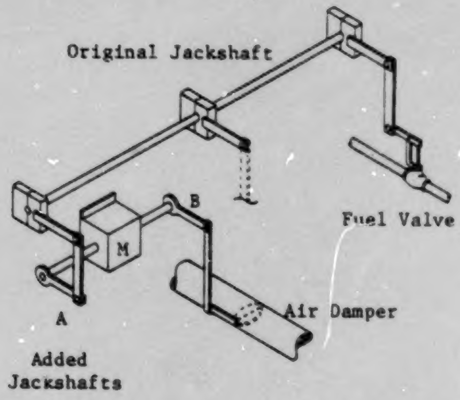

FIGURE 5. AUXILIARY JACKSHAFT TRIM MECHANISM.

A variation of this approach is to mount the mechanism M directly on the end of the original jackshaft so that the input shaft to M becomes the original jackshaft. This approach provides an advantage of not requiring the auxiliary jackshaft and the fixed mounting location it requires. It does require that the jackshaft be sturdy enough to support the entire actuator mechanism, including the motor. See Figure 6.

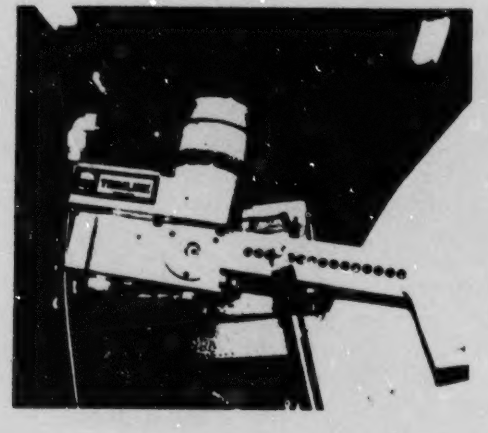

FIGURE 6. TRIM MECHANISM MOUNTED DIRECTLY ON THE JACKSHAFT.

A third mechanical configuration used to obtain the desired air/fuel ratio variation is shown in Figure 7. This patented arm is known as a Tory Link* and is normally used to replace the arm that drives the air damper connecting link. The Tory Link is simple, does not require the expense of an auxiliary jackshaft and can easily be returned to the original untrimmed mode of operation by simply pinning the floating link to the air arm. The trim actuator drives the floating link above or below the air arm to obtain the air flow trim. While the Tory Link reduces the cost of achieving the jackshaft interface, when compared to earlier techniques, it does require that the trim actuator be mounted in the plane of the floating link and that the Tory Link itself be located on a jackshaft end so that the tip of the floating link can pass through the center line of the jackshaft.

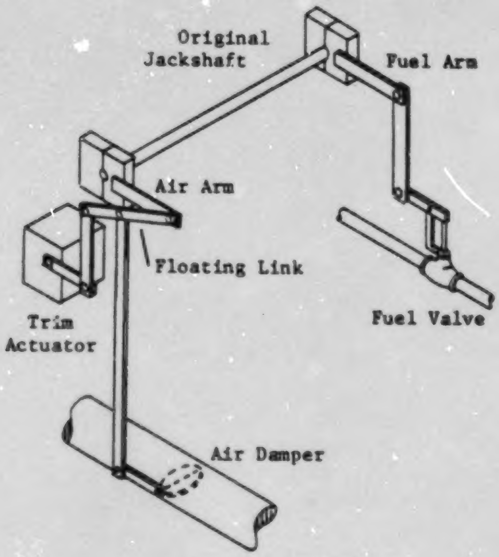

FIGURE 7. TORY LINK TRIM MECHANISM.

Each of the mechanical interfaces discussed produces a bias between air and fuel. If a ratio or percentage effect is desired, the trim controller must use boilerload information to modify its output and produce the desired effect.

Some mechanical interfaces use a trim actuator to directly obtain a ratio or percentage trim action. Figure 8 illustrates a motorized ball screw installed in the air arm driven by the jackshaft. The trim controller drives the actuator to shorten or lengthen the air arm. This action results in a percentage or ratio trim result.

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*Trademark of Westinghouse Electric Corp.

Figure 9 illustrates a variation on the auxiliary jackshaft scheme discussed earlier. In this case, the input and output shafts of the auxiliary jackshaft are connected by two positioning cylinders operating in a pre-calibrated relationship. As the range cylinder retracts, the zero cylinder extends and as the range cylinder extends, the zero cylinder retracts. The linkage calibration, established by the cylinders, dictates that the output shaft position will always be equal to the input shaft position multiplied by the percentage correction factor determined by the trim controller.

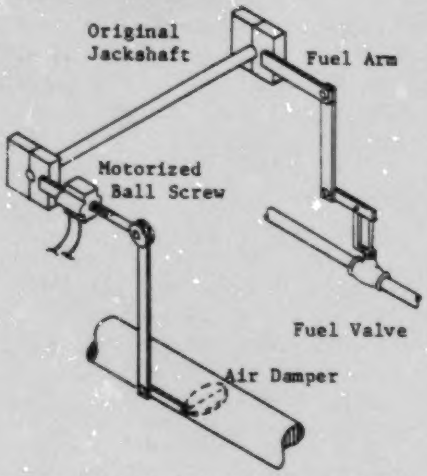

FIGURE 8. RATIO TRIM WITH MOTORIZED BALL SCREW.

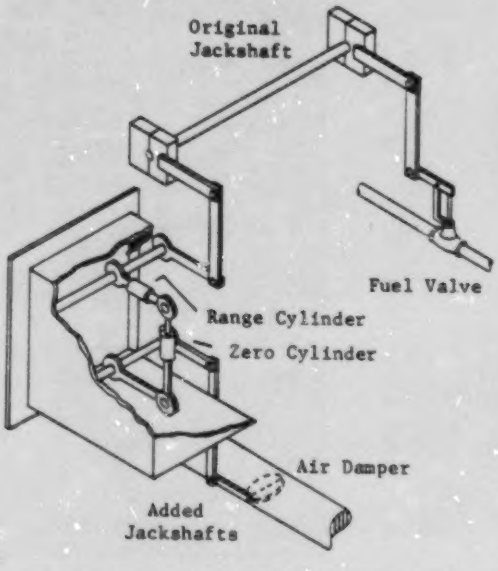

FIGURE 9. RATIO TRIM WITH PRECALIBRATED CYLINDERS.

The latter two mechanisms directly provide a ratio or percentage trim action. While this action would be desirable with an ideal burner, most burners require more excess air at low firing rates than at high rates so that, ideally, some combination of bias and ratio trim is necessary. With a bias trim mechanism, the bias can be modified with respect to boiler load if the controller has the required computation ability. Thus, it produces the desired trim control action. If the controller does not have this ability, the ratio or percentage trim action may be preferable to a bias action, especially if the burner has a wide range of operation. The requirements for ideal trim control action will be discussed in the next section.

A very recent development in achieving the jackshaft interface is expected to significantly reduce the cost and complexity of installation. The installation requires no change in the jackshaft or its arms. The mechanism is a small lightweight expanding and contracting link branded VeriLink*. It is inserted in the short link connecting the air arm on the jackshaft with the air damper. Figure 10 shows the VeriLink installed and replacing the original link. The motor actuator that drives the link may be mounted anywhere in the vacinity without regard for location or alignment. It is overtravel protected to prevent damage to the linkage or the damper and is capable of automatically moving to the neutral position even when the trim controller fails. In addition, it is small enough to mount in very small linkage. One size is adequate for 100 HP to 500 HP packaged boilers and a larger unit is available for larger industrial boilers. Since it produces a bias-type trim action, it should be used with a smart trim controller capable of using boiler load information to modify the trim action.

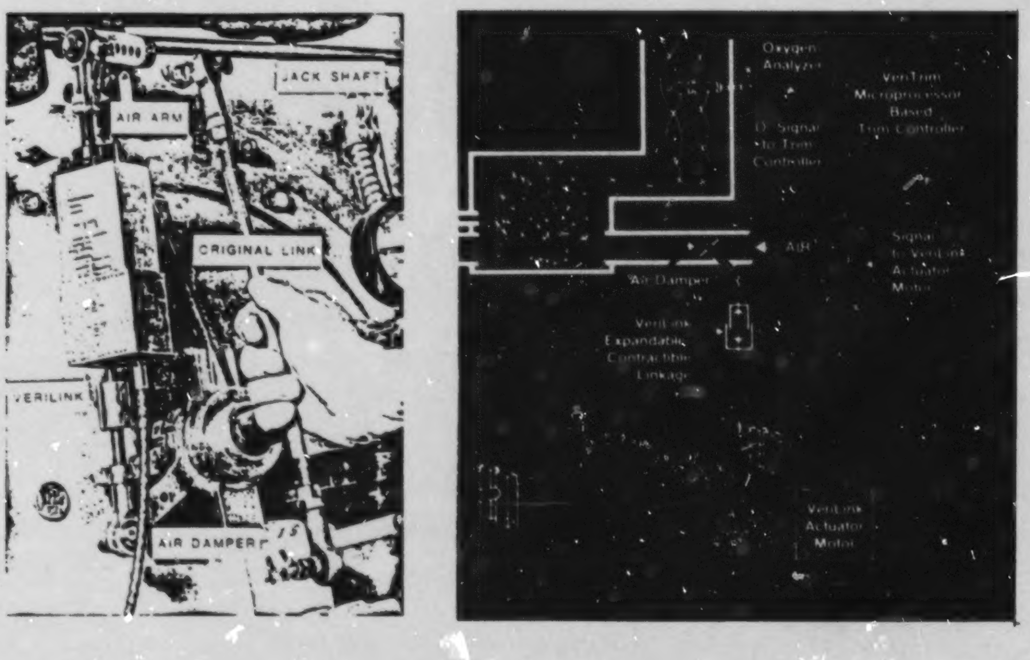
JACK SHAFT
AIR ARM
ORIGINAL LINK
VERILINK
AIR DAMPER
Oxygen Analyzer
VeriTrim Microprocessor Based Trim Controller
O2 Signal to Trim Controller
AIR
Air Damper
Signal to VeriLink Actuator Motor
VeriLink Expandable Contractible Linkage
VeriLink Actuator Motor

FIGURE 10. EXPANSION - CONTRACTION VERILINK INSTALLED IN PLACE OF EXISTING CONNECTING LINK.

*Trademark of Westinghouse Electric Corp., Patent Applied For

While all of the trim mechanisms described can be installed to trim air or fuel, it is usual practice to trim air so that the trim control does not interfere with the steam pressure or water temperature control.

The steam pressure control loop controls energy release to maintain pressure. Disturbances in air input do not significantly alter this release whereas fuel input modifications do. Fuel trim has the additional disadvantage in requiring multiple trim mechanisms when more than one fuel is fired.

Figure 11 illustrates a trim control scheme that trims fuel by changing the normal fuel supply pressure. The normal fuel pressure is raised or lowered by the oxygen controller in order to increase or decrease fuel flow. The resulting trim control is a ratio trim since flow is increased or decreased by a certain percentage at all boiler loads.

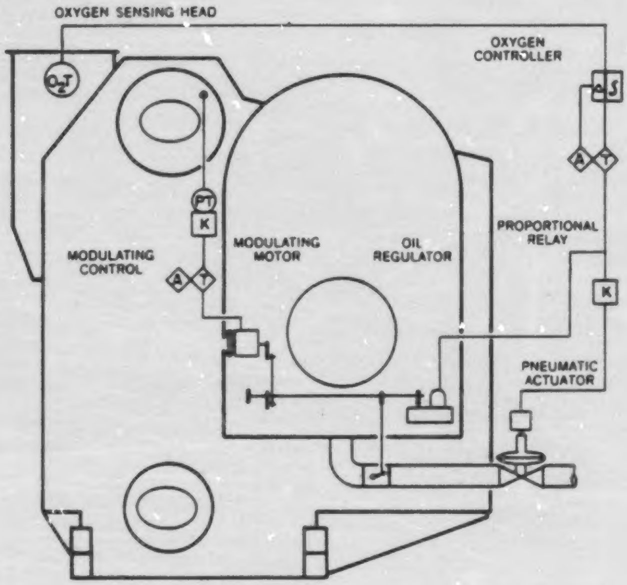

FIGURE 11. OXYGEN TRIM CONTROL USING FUEL TRIM.

Regardless of the mechanical interface selected for trim control, there are two requirements that are essential if the interface is to fulfill the functions required by the overall control system.

1. Safety - The trim actuator should have position feedback so that the controller can position it to the neutral or no-trim position when the trim control is disabled or when abnormal conditions are encountered. It should also be capable of driving to the neutral or disabled condition if the trim controller itself fails.

2. Overtravel Protection - The trim actuator should not be capable of damaging linkage if the air damper encounters a stop or seat. This means that some form of protection against excessive force should be included in the trim mechanism.

Bias Vs. Ratio Trim

As we have described, the jackshaft interface mechanics can produce a bias of air or a percentage change of air. Figure 12 illustrates the normal air and fuel relationship for an ideal burner. An ideal burner is capable of mixing air and fuel in equal percentages even at minimum flows. For such a relationship, a ratio trim system (shown) produces equal variations in flue gas oxygen for equal controller output variations. As a result, the oxygen control response is equal at high and low loads.

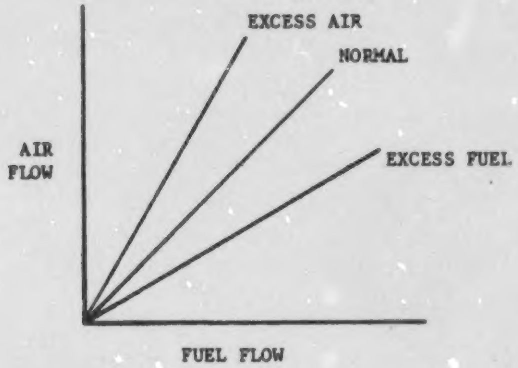

FIGURE 12. RATIO TRIM RESULTS FOR AN IDEAL BURNER.

For a similar burner, Figure 13 shows how a bias trim alters the air-fuel ratio with load. Note that at low firing rates, a bias trim produces excessive air/fuel ratio changes. This means an oxygen trim control would oscillate badly at low loads if properly tuned at high loads.

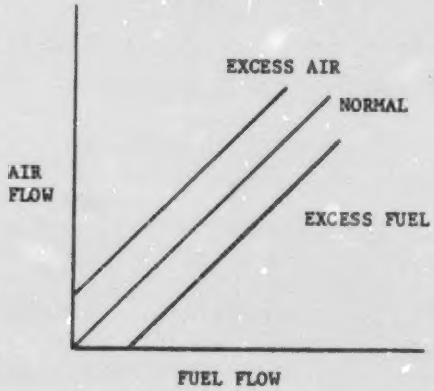

FIGURE 13. BIAS TRIM RESULTS FOR AN IDEAL BURNER.

Figure 14 illustrates the normal air and fuel relationship for a burner requiring an excess of air to burn all the fuel at low fuel inputs. A ratio trim action (shown) produces large changes in excess oxygen at high loads and very little change at low loads. As a result, for burners that require excess air at low loads (as most do), a ratio trim system produces significant excess oxygen changes at high loads but almost no change at low loads.

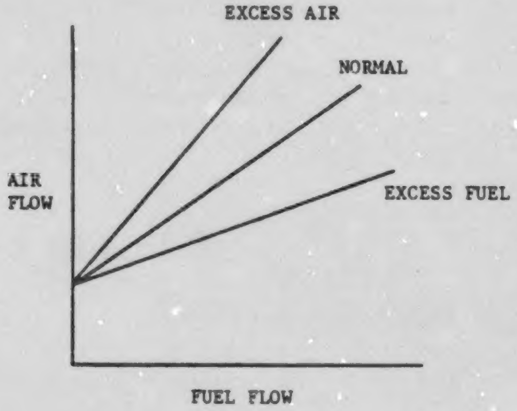

FIGURE 14. RATIO TRIM RESULTS FOR A BURNER REQUIRING EXCESS AIR AT LOW FIRING RATES.

Figure 15 illustrates the air and fuel relationship for the same burner when a bias trim is used. Notice that a bias trim alters the air/fuel ratio a little more at low loads than at high loads. Controller gain adjusted for optimum performance at high load will produce instability at low load.

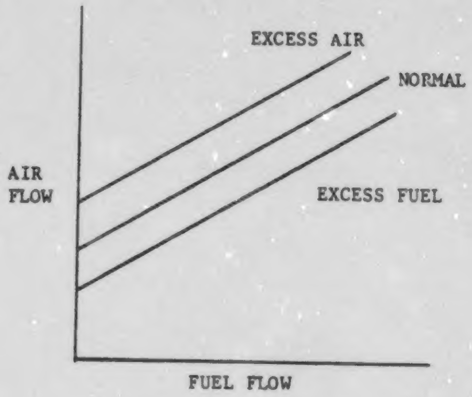

FIGURE 15. BIAS TRIM RESULTS FOR A BURNER REQUIRING EXCESS AIR AT LOW FIRING RATES.

The ideal trim controller action is illustrated in Figure 16. The intersection point of the ratio control function may be moved to obtain a combination of ratio trim or bias trim effect. If the intersection is at B, a ratio trim action is obtained. If the intersection is moved to A, the bias trim action is increased causing greater changes in air flow to occur at low firing rates. By selecting the proper trim controller action, optimum gain of the oxygen control system can be obtained for the actual burner characteristics. In practice, this means fast stable control action can be obtained over the entire firing range.

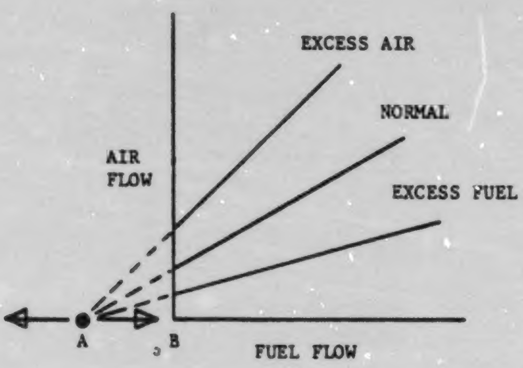

FIGURE 16. COMBINATION BIAS AND RATIO TRIM ACTION FOR A BURNER REQUIRING EXCESS AIR AT LOW FIRING RATES.

Figure 17 illustrates the typical trim actuator position versus load as a result of ratio trim action (curve where trim position is zero at zero load) and as a result of combined ratio and bias trim action (outer curve).

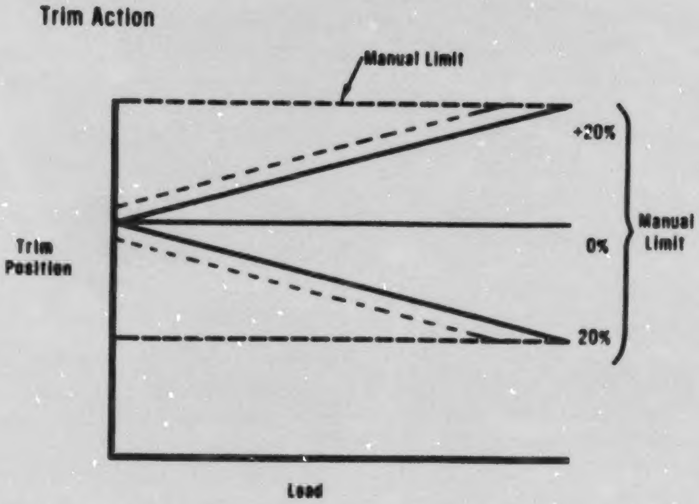

FIGURE 17. TRIM ACTUATOR POSITION VERSUS BOILER LOAD FOR RATIO TRIM (SOLID) AND COMBINATION BIAS AND RATIO TRIM (DOTTED).

Programmed Oxygen Set Point

An ideal burner would operate at the same air/fuel ratio, and hence, the same oxygen set point at all firing rates. An oxygen trim control system would, therefore, operate with a fixed excess oxygen set point. However, actual burners require more excess air at low firing rates than at high and, therefore, the oxygen set point must be altered as load changes. If a fixed set point controller is used and is set properly at high load, unburned fuel losses will occur at low loads and if set properly at low loads, excess flue gas losses will occur at high loads.

A typical programmed oxygen set point is shown in Figure 18 and can be achieved by measuring the boiler firing rate and generating a set point as a function of that rate. This is usually accomplished by using the jackshaft position as a measure of firing rate. A potentiometer mounted on the jackshaft drive motor shaft, a separately mounted potentiometer connected to a jackshaft arm or a cam driven pneumatic signal generator can be used.

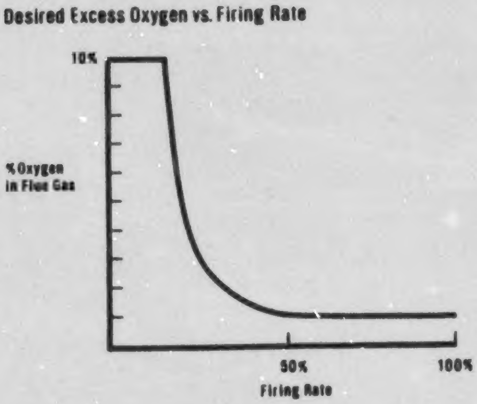

FIGURE 18. TYPICAL PROGRAMMED OXYGEN SET POINT.

Static Vs. Dynamic Trim Control

The proliferation of oxygen trim control systems for small boilers raises the question of difference in their performance and safety. Is it as simple as sensing the excess oxygen in the stack and moving the trim control mechanism until the excess oxygen matches the set point? Figure 19 illustrates the simplest form of what some people define as a trim control. If stack oxygen exceeds the set point, the trim motor

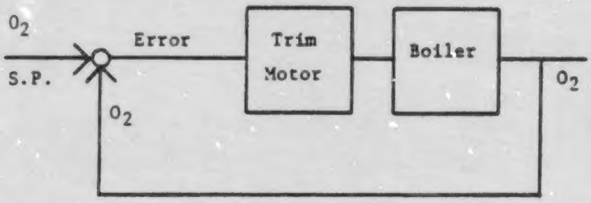

FIGURE 19. SIMPLE INTEGRATING TRIM CONTROL.

drives slowly to decrease air. If stack oxygen is less than the set point, the trim motor drives slowly to increase air. If the trim motor moves slowly enough and the trim mechanism produces a reasonable balance between bias and ratio trim to satisfy the burner characteristics and if the combustion process and oxygen sensor lag are short enough, the system can be made stable.

If, however, the boiler load suddenly changed from a high firing rate condition to a low firing rate condition where the burner requires more excess air, as most do, the air/fuel ratio would change to a dangerously rich condition because the trim motor has moved too slowly to alter the excess oxygen to the new higher value. This simple form of trim control can only be safe if no transients are encountered or if the oxygen set point is established at the highest safe set point for the boiler load requiring the most excess air. This procedure, however, would normally prevent maximizing the fuel savings. This type of trim control should be avoided unless it is built into the burner or boiler by the manufacturer and its performance has been tested under all static and dynamic load conditions.

Figure 20 represents a trim control system design with major improvements. It incorporates four major features considered essential to oxygen trim control when applied to existing installed jackshaft boilers.

1. A signal representing firing rate or boiler load is used to develop a varying oxygen set point matching the burner requirements for greater excess oxygen at low firing rates.

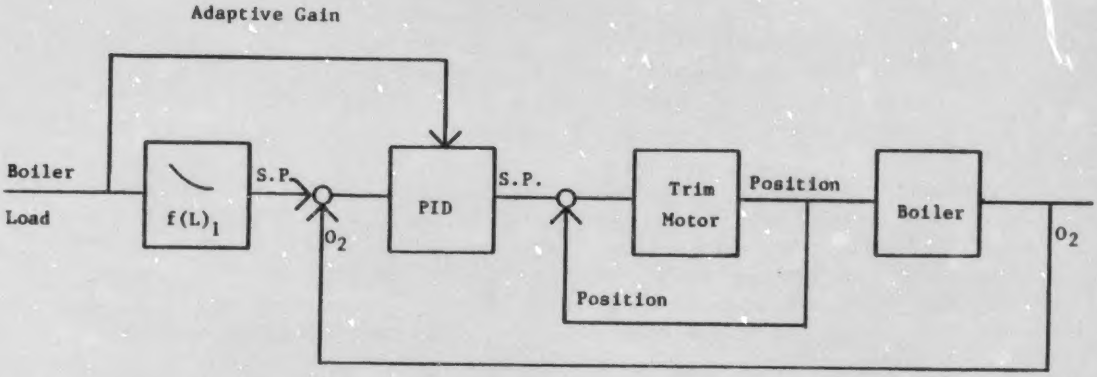

FIGURE 20. ADVANCED TRIM CONTROL.

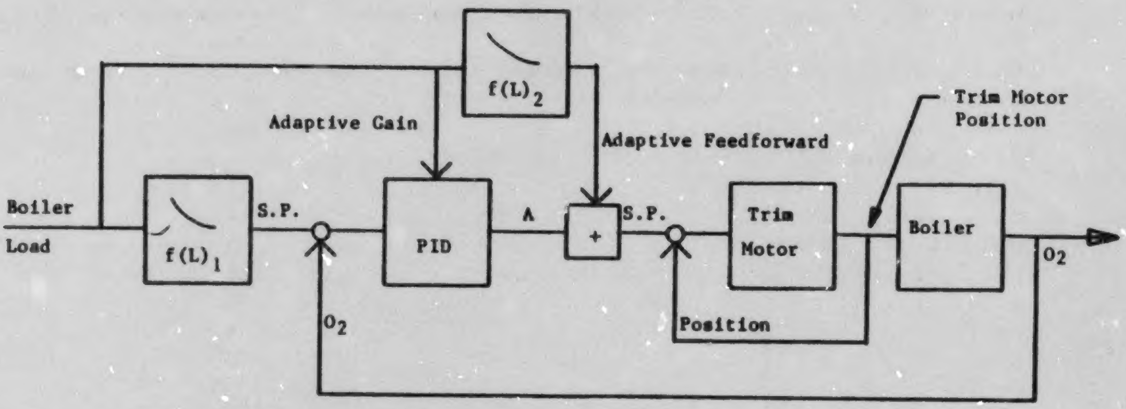

FIGURE 21. ADVANCED TRIM CONTROL WITH ADAPTIVE FEEDFORWARD.

2. A PID controller (proportional plus integral plus derivative) is used rather than the pure integrating action of the earlier described system, providing flexibility in tuning.

3. Boiler load or firing rate information is used to alter the gain of the trim controller (adaptive gain [illegible] obtaining the amount of bias and ratio control action required for the existing burner and linkage characteristics. If properly adjusted, the loop gain in the oxygen control loop will remain constant at all boiler firing rates so that stable operation with maximum speed of response is obtained at all loads.

4. Position feedback is added to the trim actuator so that faster motor operation can be used when required, without affecting stability. In addition, it allows the trim actuator to be positioned at its neutral or disabled position whenever safety conditions warrant.

A recent development in trim control design can produce a major improvement in dynamic performance of air/fuel ratio control for jackshaft boilers. This development provides instantaneous action to alter the relationship between the fuel valve and the air damper as boiler firing rate changes without requiring any oxygen deviation from the programmed oxygen set point. This action is accomplished by the addition of an adaptive feedforward element as shown in Figure 21. This characterizing element allows one to electronically alter the original mechanical relationship between the fuel valve and air damper as the jackshaft moves through its full load range. It optimizes the characteristic that should have been built into the cams or linkage angularity provided by the boiler manufacturer. This feedforward action, working through the trim actuator yet independent of the final oxygen control loop, moves with a speed equal to jackshaft speed, obtaining the ideal mechanical relationship sought when the cams or linkage angularity of the jackshaft was designed.

As in the earlier described function generator used to characterize the oxygen set point with load, this adaptive feedforward characteristic should be tailored to the specific fuel and burner being used.

Figure 22 illustrates the typical trim actuator position versus load as a result of the adaptive feedforward characteristic and Figure 23 shows the combination of the feedforward and the combined ratio and bias trim action shown earlier in Figure 17.

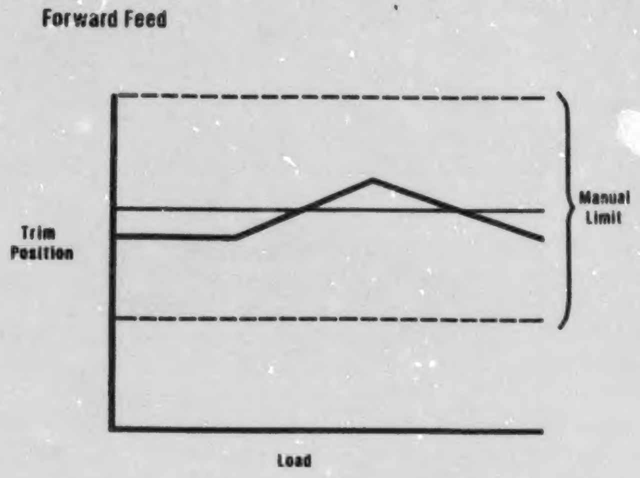

FIGURE 22. TRIM ACTUATOR POSITION RESULTING FROM FEEDFORWARD.

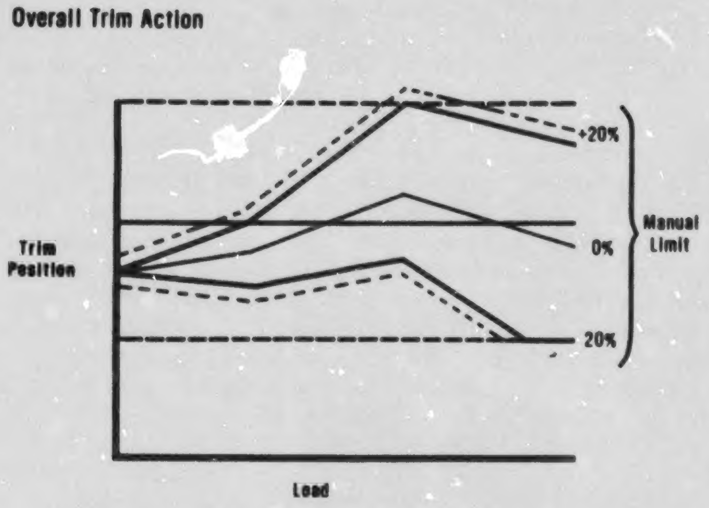

FIGURE 23. TRIM ACTUATOR POSITION RESULTING FROM FEEDFORWARD AND THE RATIO AND BIAS TRIM.

Developing the information and calibrating the control system to obtain the desired characteristics for the oxygen set point and the feedforward signal can be done by an experienced service technician. However, the decreasing cost and increasing power of microprocessor hardware makes it possible for this function to be performed automatically by a learning capability built into the trim controller. By simply operating the boiler at several fixed firing rates and manually adjusting the trim actuator to obtain the desired oxygen value at each load, it is possible for a microprocessor to learn and calibrate itself via a simple push button procedure. This ability reduces the skill level required to set up and calibrate a system.

Multiple Fuel Firing

During the Middle East oil embargo and the later natural gas shortage, most boiler operators were forced to look at fuel alternatives. Home owners were protected against cutoff but industrial and commercial users were under increased pressure to provide alternatives. As a result, oxygen trim controls designed for single fuel firing were not considered adequate if users were to be prepared for future shifts in fuel availability.

In the advanced trim control system, described earlier, there are a number of elements that are fuel or burner dependent. They include:

1. The boiler load vs. oxygen set point characteristic (See $f\ (L)_1$ in Figures 20 and 21).

2. The adaptive gain parameters of the trim controller (See Figure 20 and 21).

3. The adaptive feedforward characteristic. (See $f\ (L)_2$ in Figure 21).

As a result of these fuel dependent requirements, it is essential that for each fuel, the trim controller incorporate separate characteristics for each of these three control functions if advanced trim control is to be implemented.

Figure 24 illustrates the block diagram of a single card, two fuel microprocessor with appropriate software for advanced trim control, learning mode calibration capability and semi automatic analyzer calibration. If fuels are changed only rarely, selection of the fuel can be made manually by pushing a button. If changes are frequent, contacts driven by the fuel shutoff valves can be used to instruct the control to use the right characteristic data.

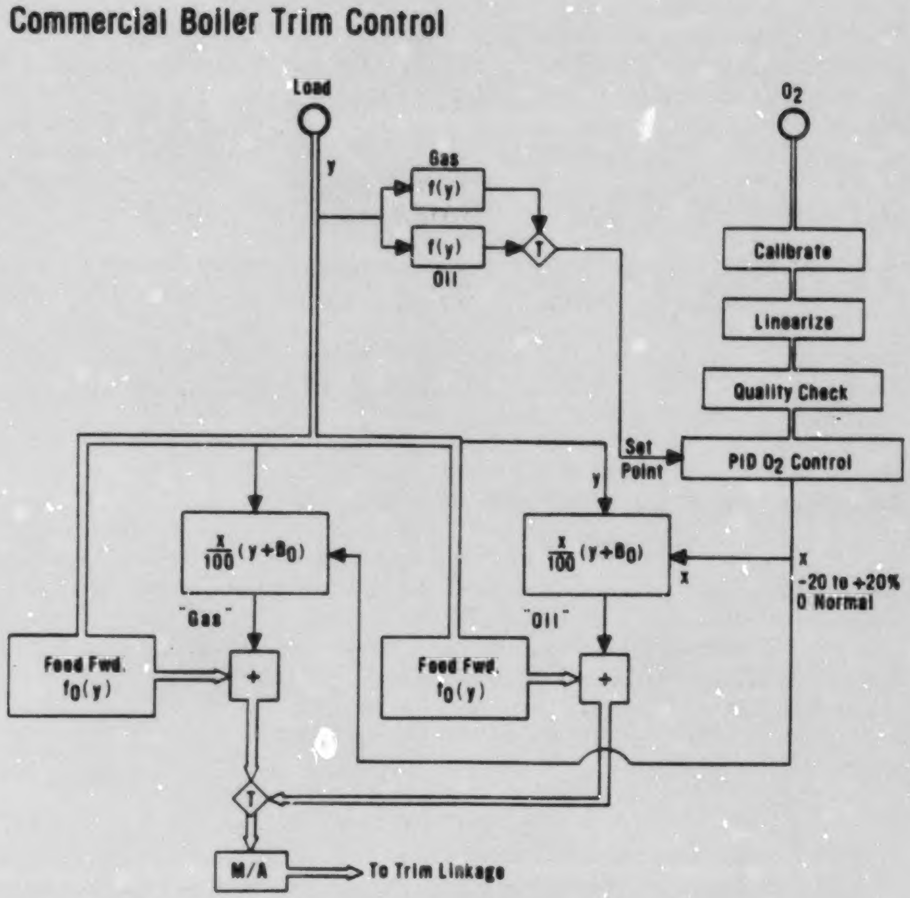

FIGURE 24. BLOCK DIAGRAM OF AN ADVANCED TRIM CONTROL SYSTEM WITH ADAPTIVE FEEDFORWARD AND LEARNING MODE CALIBRATION.

Oxygen Measurement

The steady state accuracy with which the final air/fuel ratio is controlled is determined primarily by the oxygen sensor itself. The sensor should be accurate, fast, reliable, as maintenance-free as possible and should be verifiable with precision test gases without removing the analyzer from the stack.

While there are several ways to measure excess oxygen in the stack on a temporary basis using a portable sampling analyzer, the invention of the zirconium oxide solid electrolyte sensor by Westinghouse in the late 1960's virtually eliminated all other techniques for sensing oxygen in the stack of combustion processes on a continuous basis. This cell operates at high temperature so that it can be placed directly in the stack without fear of altering the flue gas measurement due to condensation or sample conditioning. (See Figure 25)

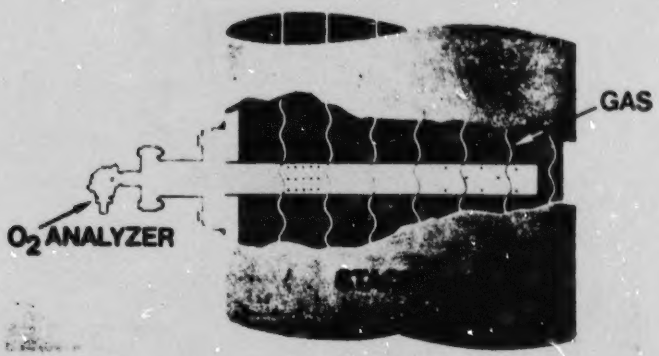

FIGURE 25. IN SITU OXYGEN ANALYZER WITH MEASURING CELL IN THE STACK.

In some cases, the cell is outside the stack (ex situ) and flue gas is pumped or aspirated to the cell for measurement. Figure 26 illustrates a typical analyzer of this type. While usually lower in cost because the oven required to keep the cell at constant temperature can be outside the stack, the reliability of the measurement is lessened because dirty flue gas flows through the sample line and eventually plugs it preventing the flue gas from reaching the cell.

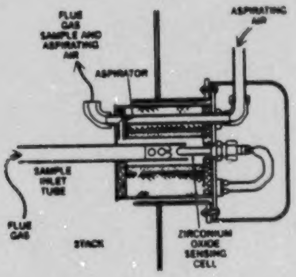
FLUE GAS SAMPLE AND ASPIRATING AIR
ASPIRATING AIR
ASPIRATOR
SAMPLE INLET TUBE
FLUE GAS
STACK
ZIRCONIUM OXIDE SENSING CELL

FIGURE 26. SAMPLING TYPE OXYGEN ANALYZER.

Oxygen analyzers that mount the cell directly in the stack (in situ) have become universally accepted for most industrial combustion processes. The in situ analyzer's reliability is very high because the flue gas diffuses to the cell and no flow occurs. Since there are no sample lines to plug and no fouling condensation occurs, operation can be virtually maintenance free.

Although industrial use of the in situ analyzer is widespread, only recently has its cost decreased to where it can be cost-effective on small jackshaft boilers.[1,2,3,4,5,6,7] Figure 27 illustrates a commercial version of this oxygen analyzer for jackshaft boilers.

FIGURE 27. COMMERCIAL IN SITU OXYGEN ANALYZER FOR SMALL BOILERS.

For high accuracy of oxygen measurement, it is essential that the cell be held at constant temperature and that the cell can be verified or calibrated with known test gases. This procedure is usually accomplished by applying two known test gases in series so as to purge the cell area and note the cell output. A single test gas can be used to check the zero but two gases are required to check slope. The quality of a zirconium oxide cell can be evaluated by its cell resistance and its output slope. Checks on these two parameters at set intervals can indicate change in quality and the need for recalibration.

In the past, it has been normal practice to calibrate by checking with test gases, plotting the data and setting the zero and span to match the data. With low cost microprocessor capabilities, it is now possible to check cell resistance automatically and completely recalibrate the probe automatically by manually introducing the two test gases and allowing the microprocessor to do the zero and span computation and data loading. This semi-automatic calibration can be carried out even on small jackshaft boilers using inexpensive portable test gases.

Operator Interface

Combustion control systems on jackshaft boilers generally have very few operator controls. Most operate without attention by any operator. Most do have a manual/automatic selector switch that allows you to put the jackshaft drive actuator on manual and base load the boiler by pushing an increase-decrease button to increase or decrease firing rate.

Oxygen trim controls need not change this situation. The advanced trim control systems, described earlier, do not require operator intervention unless alarms indicate some abnormal condition has occurred. A button to disable the trim control and return the trim actuator to neutral and perhaps a manual/automatic switch with increase/decrease buttons to manually position the trim actuator are all that are essential.

Since many small boiler rooms are not secure, it is desirable to have any operator controls under lock and key.

If an operating engineer or an in-house maintenance department are available, it may be desirable to have additional displays built in to aid monitoring and/or recording of boiler load, oxygen set point, stack oxygen content, stack temperature, trim actuator position or combustion efficiency. If maintenance and evaluation are carried out by outside contractors, these displays could be incorporated into a plug in portable display module that could be brought in when any servicing is required. Figure 28 illustrates a recently introduced microprocessor-based oxygen trim control package that has operator interface displays built in. The 3 1/2 digit display will indicate any of the variables mentioned earlier as well as any of the diagnostic and micro-computer parameters that might interest the service technician.

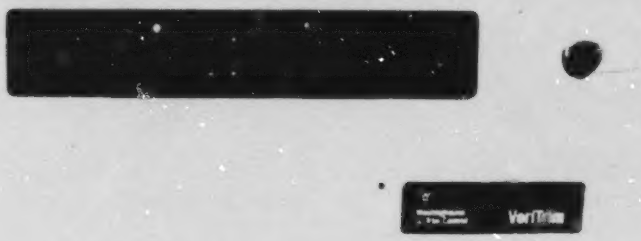

FIGURE 28. MICROPROCESSOR-BASED TRIM CONTROL WITH BUILT-IN OPERATOR INTERFACE.

This same package is available at lower cost without the operator interface display built in so that if a number of boilers are involved in the same plant or if service is performed by an outside contractor, a separate hand held loading and display module can be shared among many trim controls. Figure 29 illustrates such a module. In this case, the trim control package needs only a single LED to indicate normal operation or a need for service.

FIGURE 29. HAND HELD TRIM CONTROL SERVICE MODULE.

The addition of the microprocessor to oxygen trim control can produce an expansion of the information base available to the boiler owner. If the software is properly designed, he can select any of the information available to the trim control as well as information that can be computed.

For example, the microprocessor can be designed to provide a few analog outputs that can be selected and scaled to provide trend recording of valuable relationships that were never previously available. Information can be developed on:

1. The quality of the original jackshaft calibration (before trim addition) by studying the relationship betwen the load or jackshaft position signal and the trim actuator signal. Excessive one sided trim bias signals indicate readjustment of the basic linkage might be advisable at the next boiler tune-up.

2. The quality with which the ratio and bias trim functions have been set by observing the oxygen change resulting from an oxygen control loop output change (Point A in Figure 21) at high and low loads. When these are equal, we have constant loop gain in our oxygen loop.

3. The comparative performance between burners on two or more boilers by comparing the oxygen set point against jackshaft position for each of them.

4. The status of soot formation on fire tubes by comparing stack temperature, excess air (oxygen) and boiler load immediately after cleaning compared to the present condition. This comparison can be further simplified by asking the micro to compute combustion efficiency as defined in the earlier "stack losses" section of this paper and then compare this calculated efficiency against boiler load over a period of time.

5. The comparative combustion efficiency between boilers by comparing the combustion efficiency vs. boiler load characteristic of one boiler with another. This will allow you to exercise boiler usage optimization even in a small boiler room.

Summary

As you can see, the availablity of low cost, highly reliable, in situ oxygen analyzers and low cost powerful microprocessor technology have brought cost-effective, fuel-saving oxygen trim control to small jackshaft boilers and heaters. Microprocessor technology makes possible powerful and sophisticated combustion control capabilities at a cost that can produce one year paybacks on boilers as small as 150 HP. Yet in spite of the advanced nature of these control systems, the user friendly operator interface and the built in intelligence to robotically learn and self calibrate allows unsophisticated users to apply trim control to virtually every small packaged boiler or water heater.

New mechanical interfaces capable of modifying the relationship between the air and fuel linkage on jackshaft boilers without expensive modifications or installation difficulties has significantly reduced the installed cost. A field retrofit installation of an advanced microprocessor based system with in situ oxygen analyzer, boiler load signal generator and a VeriTrim jackshaft interface is shown in Figure 30. Total installed cost was well under $10,000. One year paybacks are possible when boiler fuel bills exceed $100,000/year or two year paybacks when fuel bills exceed $50,000/year.

If fuel bills presently exceed these values, it is time to explore the application of oxygen trim control to your small packaged boiler.

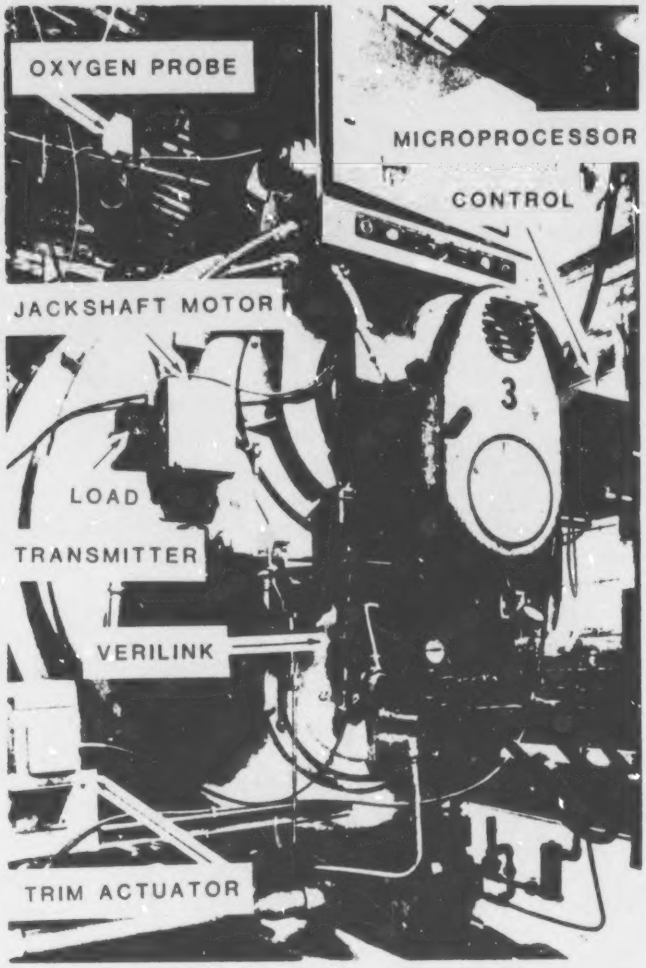

FIGURE 30. FIELD RETROFIT INSTALLATION OF AN ADVANCED MICROPROCESSOR BASED TRIM CONTROL SYSTEM.

References

1. Neuberger, Edmond D.; Reliable Oxygen Measurement Optimizes Fuel Costs; ISA 74-721.

2. Cherrington, Dean and Michelson, Herb; Exxon Research; How to Save Refinery - Furnace Fuel; The Oil and Gas Journal, Sept. 2, 1974.

3. Neuberger, Edmond D.; Relibable Oxygen Measurement Reduces Process Costs; Westinghouse ENGINEER, Jan., 1975, Vol. 35, Number 1

4. May, Donald Lynn, Monsanto Company; Cutting Boiler Fuel Costs With Combustion Controls; Chemical Engineering, December 22, 1975

5. Nelson, Robert L.; New Developments In Closed Loop Combustion Control Using Flue Gas Analysis; ISA 1980, ISBN 87665-471-X

6. Neuberger, Edmond D.; A Case For Combined CO and O_2 Combustion Trim Control; Energy Management, February, 1982

7. Nelson, Robert L.; New Developments In Flue Gas Measurement and Control; The Second Annual Control Engineering Conference, May, 1983

Managing Maintenance Information Part II

By Pete van der Have
University of Utah

Introduction

Those of you who are here today even after having heard my presentation last year in Louisville, I admire your stamina. For those of you who are listening to me for the first time, thanks for coming here rather than partaking of the much more tempting coffee and doughnuts available elsewhere.

Last year, I discussed how we got to where we are with the computerization of our management information. At the end of my time slot, I was just barely getting started on specific programs we have on our system. I will review the highlights of the core of our system in a few minutes.

After we have completed that review, I would like to share with you some of the programs we have on our Microdata 6000 Computer right now. Included will be Preventive Maintenance, Deferred Maintenance and Capital Facilities requests, Custodial Standards program, Motor Pool, and Utilities. If there is time remaining we will glance at key controls.

I would like to point out that this presentation will make little attempt at justifying our reasoning behind the creation of a program. I will mainly explore the means we have designed to help us accomplish a specified objective.

Review

Maintenance costs are stored in the Work Order Transaction file. It contains an annual total of 18,000 work order transactions. (See exhibit #1.) Each one of these is unique in that its index number is made up of three groups of numbers. The first group, of four characters, identifies the work type and the building, or cost center. The second group, consisting of six characters, refers to either a P.M. control number or a service order number, usually just called card number. The last four digits, making up the third group, indicate which shop is doing the work. Each of these numbers is matched against master tables upon input so as to decrease the margin of error.

As labor, material or other charges come in, each entry has to match an active work order transaction. Even though the cost is not posted to the work order transaction immediately, the system does automatically match those critical numbers. The individual cost transactions are checked a couple of more times for validity and then finally posted to the work order transaction file. Next, most of our management information reports are run. (See exhibit #2.) As the charges are posted to the work order transaction file they are simultaneously posted to the P.M. master file.

Are there any questions so far? Good! Now let's take a closer look at the Preventive Maintenance Subsystem.

Preventive Maintenance

The primary purpose of our P.M. program is nothing less than to optimize the use of our workforce and to extend the life of the equipment on campus. We believe that our P.M. program allows us to accomplish that goal. (See exhibit #3.)

We first established a table of action codes. Each action code is unique and can be used by one shop only. The action code, which has a four digit number as an index number, helps identify for the tradesperson what needs to be done on a particular scheduled service. The narrative of the action code uses plain English, still allowing the skilled worker the opportunity to utilize his or her own training.

The action code is a main feature of the P.M. master record. (See exhibit #4.) As you can see on this representation of our P.M. screen, the record contains information relating to historical data and scheduled services for a particular piece of equipment or system. As a permanent fixture on this record you should see (1) a card number and work order number (2) equipment nomenclature, (3) the shop primarily responsible for the maintenance of the equipment, (4) location, (5) warranty expiration date, (6) service frequency and (7) previous years' costs.

Beyond the "header" information are the scheduled services for the year which show up as line items. The first field identifies the scheduled date of service. The second field ties back to the action code table. You might note the respective action codes for individual line items may be different from each other. The third column identifies how long the shop supervisor thinks it should take to complete the service. (See exhibit #5.)

The monthly service orders are printed up a day or so before they need to be distributed. The action code is printed out in full English terms, while all the other critical information is also shown. We have chosen not to print scheduled hours on the service order, though we certainly could if we wanted to. (See exhibit #6.)

As work has been completed and charges come through, additional columns of information will appear on the screen. We are then able to see, at a glance, whether any work was done, how much time it took and how much it cost for materials and labor. We can also see whether any subsequents were issued, or work was completed later than scheduled. This information is available either on the screen or on hard copy in a variety of formats.

We believe that it is absolutely necessary to process all service orders and P.M. requests through one office. If that isn't done a lot of work will go unidentified, even if it does get completed. We use that same office to file copies of all material purchases, etc., with the right service orders. All the referencing is done by card number.

Deferred Maintenance and Capital Facilities Requests

For our purposes, the main difference between deferred maintenance and capital facilities is scope. Whether a defined project is brand-new work or re-doing existing facilities also has a bearing to some degree on its classification. As far as our computer is concerned, the information is processed in the same way, regardless of its classification.

Our department's entire staff performed two major inventories over the last several years. The first one attempted to identify each piece of capital equipment (replacement cost of greater than $499) on campus. (See exhibit #7.) We also tried to identify when it was installed and when we might expect to have to replace it. We also identified P.M. card numbers for the equipment. Now we run analyses of maintenance cost vs. replacement cost for those items on an annual basis.

The second inventory tried to identify all physical maintenance problems associated with buildings, grounds, roads and utility distribution systems. (See exhibit #8.) A deadline for completion (year) was provided for each project, project costs and identifying information.

With all of this information from both inventories on the same file, we can run meaningful reports for our administration. One example might be a detailed listing of problems and the cost to resolve those problems in any one building, and how soon that funding would probably be needed.

The information on this file is updated by input from the shops as the work is completed or no longer necessary. The cost data is adjusted through the use of an inflation factor as that becomes pertinent.

The information we generate from this data has also been useful in identifying maintenance (performance?) problems by shops, by making it more obvious that certain responsibilities are not being handled as perhaps they could be. Mainly the information is used to help request funds through more detailed justification, and to help program the scarce funds which do occasionally become available.

Custodial Standards Program

There are probably as many custodial standards' theories as there are custodial managers and consultants. Our custodial management team has a program which it has found works well in scheduling and managing its workforce of nearly 200 F.T.E. A manual program originally, it has evolved to a level of sophistication which justifies its computerization. (See exhibit #9.)

The volume of the data is the result of a room-by-room, space-by-space, fixture-by-fixture inventory of the entire campus. Square foctages, frequency of cleaning, type of floor covering, congestion, type of use, permanent fixtures, etc., are factors considered in the inventory of each space. These items of data are entered onto the file with the areas number and the room number as a reference.

A separate table is made up of time data, where the Custodial team has identified, verified, and re-verified time factors on the completion of individual tasks per unit of measure. The luxury of splitting the time table off from the space inventory lies in flexibility. We can adjust for an advance in technology (say a better, quicker vacuum) in only one computer record, rather than having to adjust the inventory file for every space where carpet exists.

There is also a little tiny table that allows us to edit for certain types of potentially recurring problems. Since most of the actual data is entered through the use of codes and abbreviations the error margin increases drastically. Especially when you are depending on individuals who don't routinely work with data entry, you have to build in control and edit function. Somehow it seems you never have enough, but you have to plan on it.

The office staff and management team of the Custodial division enter their information. They can look at data compiled by room, building or area, or by task. The fruits of all this effort will help management to verify staffing needs in existing facilities, to analyze the effect of a change of configuration and use in existing facilities, and to predict staffing needs in facilities yet to come on line. It also helps them to evaluate performance of their first-line managers. (See exhibit #10.)

Motor Pool Sub-system

Our Motor Pool operations is, by an epistle from high-on-nigh, a self-supporting service organization. Since the rest of our department isn't, that places some unique requirements on programming.

We decided it was extremely critical to have good useful cost and performance information for each individual vehicle. We are therefore collecting data on gasoline and oil purchases, repair expenses, mileage for each vehicle. (See exhibit #11.)

We have also classified the vehicles by a range of groupings. We are identifying make, type of vehicle, model year and other more specific birthmarks. This allows us to analyze the performance of vehicles, looking at them from several different perspectives. The data is both historical and current.

Probably of more immediate use to us is the classification by fleet. By University policy we have five different fleets of vehicles, named Fleet A through Fleet E. On the one extreme is the fleet which is totally "owned" by Motor Pool, and leased on a fixed monthly rate to departments on a long-term basis. At the other end there are the vehicles "owned" by departments on campus, and which Motor Pool only has to see for the required State Safety Inspection and mandatory twice a year P.M. check. There are degrees of plans in-between, including day-rentals. We have always assumed that each one of these fleet types has its own cost behavior. Through the effective use of the computer we hope to be able to analyze these patterns better over a length of time. From there we should be able to come up with an equitable charge-back and rate structure for the different fleets.

Attached to this sub-system is a departmental-account file which helps with the monthly billing cycle. Even after detail has been posted, we retain it on the file for up to six months or more. We can examine the detail if we should need to, or if the feds or the state should come to us with another restricted gasoline consumption plan.

You can see that we have intentionally designed this part of the system so that we can analyze cost information by all sorts of characteristics associated with the vehicles and their management in our Motor Pool. That same cost information is used for billing purposes. It can also be used to help determine the operating budget for this function.

Next, let me show you a little of what we are trying to do toward managing about $10 million outside of our regular maintenance operation.

Utilities Record Management

At the time this presentation is being prepared, we are working hard at computerizing our utilities information. This will supplement interactive consumption management of our Johnson Controls' system.

We will be able to keep a historical file on each of our utility meters around the campus. We will enter current month's readings on each of them. We will also provide the system with billing information from the utility companies serving us. When we get all variables plugged in, the system will provide us with

1. The most recent month's consumption, both per meter or per group of meters.

2. Comparisons of consumption trends of present vs. past, perhaps allowing a five year window.

3. Billing calculations for those meters where we have to collect refunds, using current month cost data from our suppliers.

4. A cleaner, quicker method for determining how effective our JC/80 is--to monitor cost avoidance and payback.

The program is about 80 percent developed as of April 1, with an anticipated completion date of July 1. We are finding the most difficult problem to overcome is the variable factors on gas, since some of those factors vary from month to month and from meter to meter.

Our aim is to allow non-data processing people to enter the data and assume the responsibility for the accuracy of the output, least of which is certainly not the billing going out to our "customers".

Let's now take a quick look at our key control program.

Key Control Program

Perhaps we would be better off calling our program (and I suspect many others) a key monitoring or a key tracking program. The control responsibility often lies somewhere else, if it lies anywhere at all. What we try to do is to collect and provide the information those individuals who have that responsibility, by definition within university policy.

Our sub-system designed to accomplish this task consists of two main parts. First, we have a department table which consists of a home department number, the correct name of the department, and the name of only one individual (usually the head honcho) authorized to sign the Request for Keys forms from that department.

The other portion of this sub-system is made up of 99,999 slots. Each one of these slots represents one hook number. One hook number represents one lock, theoretically the same one forever. As part of the lock's nomenclature, the building number, the room number, and the classification of the keys cut per that hook number: Grand-master, Sub-master, Room, etc. We have also allowed room for special comments such as, "Keys for this area can only be issued subject to Dr. Jones' approval".

Under each hook number there are 500 slots, identified as issue numbers, which will show us the identification of individuals holding keys. After each assigned issue number we can see the holder's status (Faculty, Staff, or Student) social security number, the individual's home department number and when the key was issued. (See exhibit #12.)

As the department number is being entered, the authorized signer's name shows on the screen. This allows the operator to compare that immediately with the signature on the form. If there's no-match, the form is returned without a key.

Departments are required, by policy, to provide us with information regarding a holder's status. Theoretically, when a person leaves the campus permanently, a copy of each key request issued for keys for that person during his or her tenure, with the key attached to it is returned to us. Realistically, this doesn't always happen. We therefore insist that all departments regularly review print-out of keys issued under their department number.

We can also prepare listings of keys by hook number, by building number and by social security number. All of these are used at one time or another by police, or auditors or ourselves. One short-coming of the way we originally designed this system is that it is time-consuming to pull off information for one social security number, because the primary reference is by hook number. However, that is being (hopefully by now has been) corrected through the creation of a cross-reference file. This will allow us to put in one social security number and have all the keys issued to that individual appear instantly on the screen.

As a next step, we will design a program to construct lock combinations for a building. The system will also keep track of all combinations used, and what settings need to be used to cut keys for a particular area. We are aware that there is some software out on the market already which accomplishes much of this. Some of the concepts which will likely be used in building our routine could in some cases have been suggested rather strongly by some of the literature that's out on the market. We will also be adding some features which may be unique for us. I'll be able to address this more fully in the near future.

Conclusion

The programs which we now have in operations are intended to help make our managers more effective. We will persist with that philosophy in designing future programs. Another aim we try to maintain is that we should accomplish this without making life more difficult for the people out there with the tools, trying to get the job done, and without making them feel unnecessarily threatened. Frankly, it has taken a couple of years for our managers and supervisors to start accepting computerization. It is therefore very unlikely that the rank and file could have accepted it any easier. We do notice an increase in the level of acceptance, however, which in turn has tended to bring on a higher degree of accuracy in the data. We tend to believe that this progress is due to at least one basic philosophy we try to maintain. Our shop supervisors provide a tremendous amount of input into their respective programs. For example, nothing is added, deleted or changed on any shop's P.M. program without total input and approval of that shop's supervisor. And we're going one step further. We have developed a series of teaching programs which will help managers build their own little programs to run against selected files. This means that supervisors and managers who have no computer experience, but who have enough guts to overcome any computer-phobia they might have, can collect a variety of data. I probably don't need to point out the fringe benefits from this approach.

In summary, we have in place either virtually or actually, programs addressing all major aspects of operating a university maintenance department. Preventive Maintenance, other kinds of daily maintenance, re-billed work, deferred maintenance, custodial standards, utilities, Motor Pool and Key Control have all been computerized. In some cases, the process has taken 15 years to mature, for other programs only a couple of years. In all cases, we are now able to generate a useful array of reports for all levels of management. We can continuously convince higher level administrators that we do know what we're doing, while time and time again we're discovering that there's continuous room for improvement in the way we're managing our resources.

Thanks for listening to me and for your questions. I'll be happy to stick around for a while to answer additional questions.

SYSTEM FILE RELATIONSHIPS

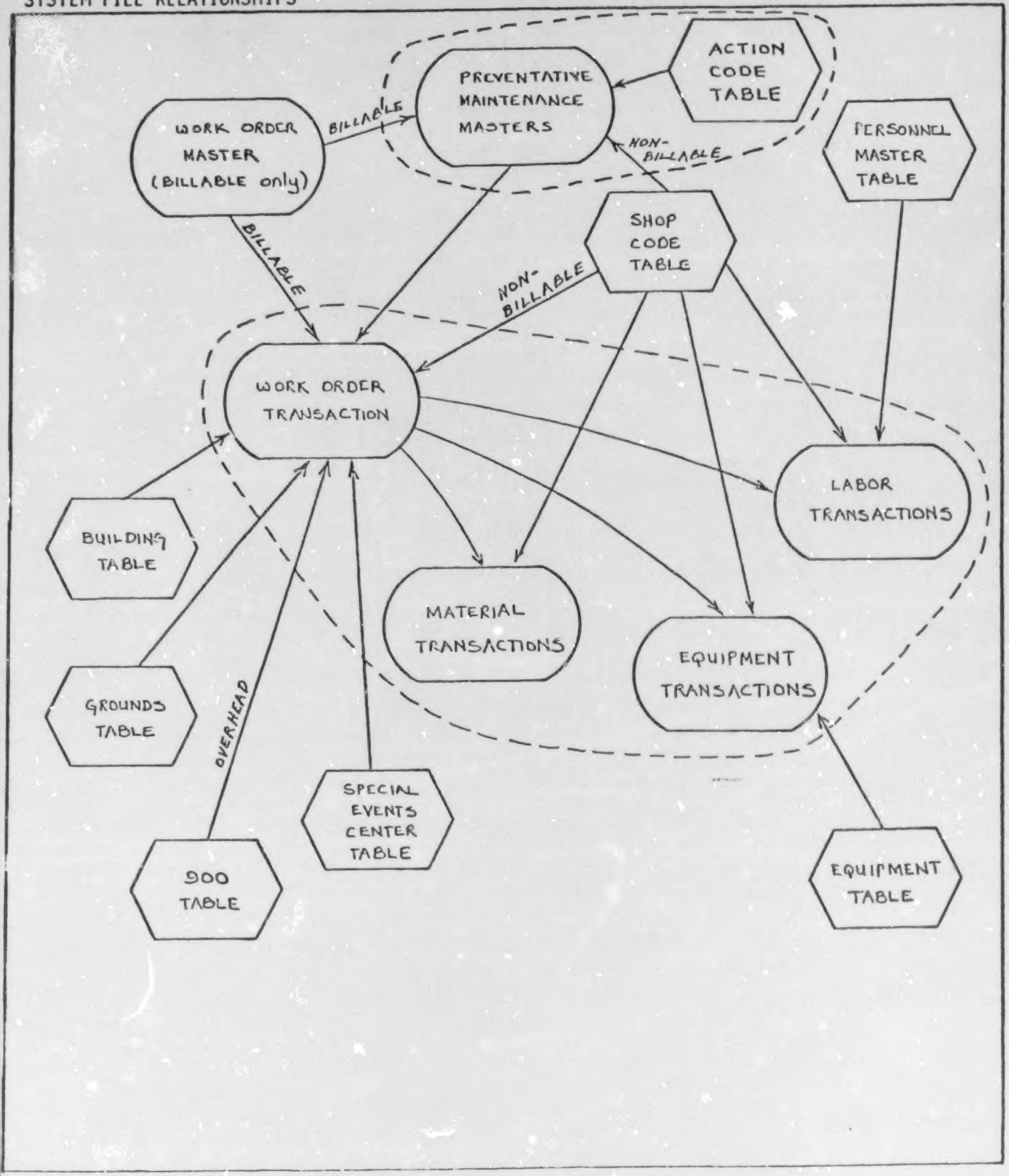

EXHIBIT #1

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PAGE 16

RUN DATE: 07:55:41 01 JUL 1983

PLANT OPERATIONS
BUDGET STATUS REPORT
WEEKLY SUMMARY REPORT FOR PERIOD: 25 JUN 1983 TO: 30 JUN 1983

TOTAL YEAR DAYS: 365 100%
YEAR-TO-DATE DAYS: 365 100%
REMAINING DAYS: 0 0%

SHOP: 3-014
PAINT

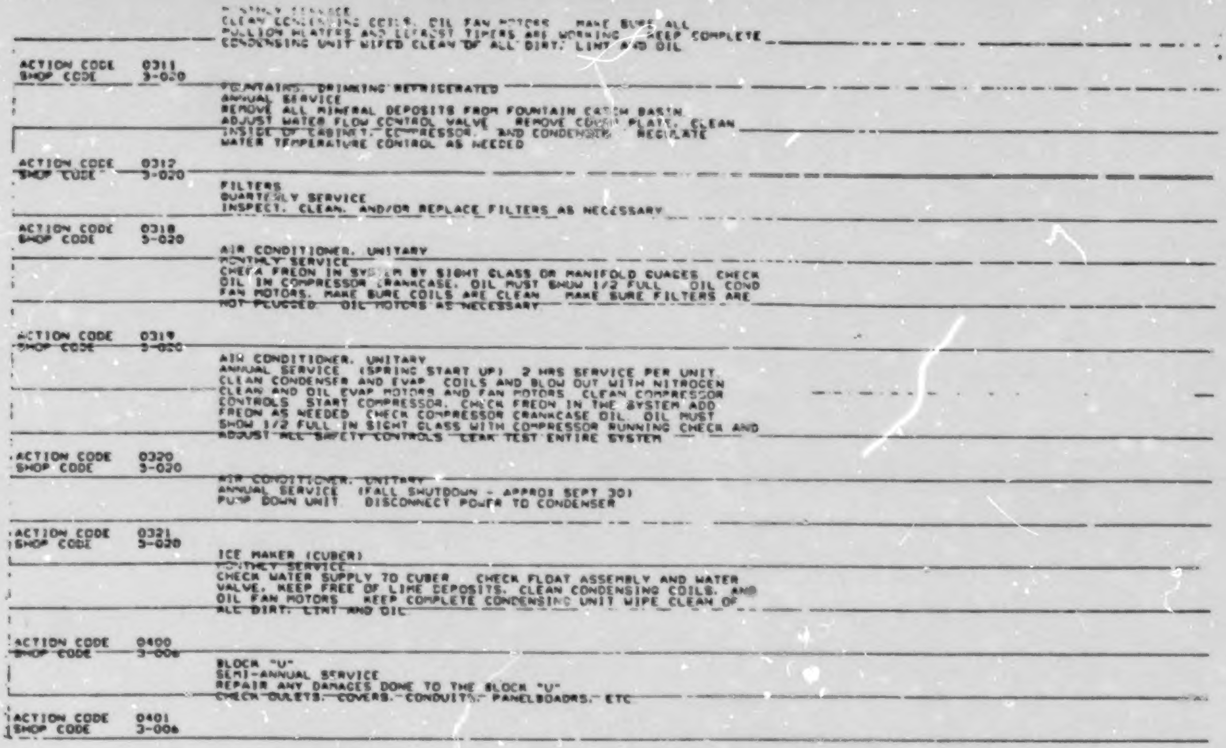
DESCRIPTION	CURRENT ACTIVITY BUDGET	PRIOR WEEK	THIS WEEK	***** YEAR-TO-DATE *** BUDGET	ACTUAL	ANNUAL BUDGET	REMAINING BUDGET	PERCENT REMAINING
SALARIES :	28,074	5,173	4,212	280,424	256,562	280,424	23,862	9%
HOURLY :	0	1,606	1,506	657	36,684	657	< 36,027>	-5484%
OVERTIME :	168	0	0	326	158	326	168	52%
PREMIUM O.T. :	84	0	0	163	79	163	84	52%
CONSTRUCTION:	< 5,574>	< 56>	< 441>	< 27,058>	< 21,925>	< 27,058>	< 5,133>	19%
NET WAGES :	22,753	6,723	5,277	254,512	271,557	254,512	< 17,045>	-7%
SUPPLIES :	7,896	242	404	55,151	47,659	55,151	7,492	14%
VEHICLES :	1,476	< 89>	0	12,036	10,560	12,036	1,476	12%
REFUNDS :	< 0>	< 195>	< 64>	< 0>	< 5,190>	0	5,190	0%
OTHER :	0	0	0	0	0	0	0	0%
T O T A L :	32,126	6,742	5,618	321,699	324,585	321,699	< 2,886>	-1%

246

270

27

EXHIBIT #2



```
                                MONTHLY SERVICE
                                CLEAN CONDENSING COILS. OIL FAN MOTORS   MAKE SURE ALL
                                MULLION HEATERS AND DEFROST TIMERS ARE WORKING   KEEP COMPLETE
                                CONDENSING UNIT WIPED CLEAN OF ALL DIRT, LINT AND OIL
ACTION CODE    0311
SHOP CODE      3-020
                                FOUNTAINS. DRINKING REFRIGERATED
                                ANNUAL SERVICE
                                REMOVE ALL MINERAL DEPOSITS FROM FOUNTAIN CATCH BASIN
                                ADJUST WATER FLOW CONTROL VALVE   REMOVE COVER PLATE. CLEAN
                                INSIDE OF CABINET. COMPRESSOR.  AND CONDENSER.   REGULATE
                                WATER TEMPERATURE CONTROL AS NEEDED
ACTION CODE    0312
SHOP CODE      3-020
                                FILTERS
                                QUARTERLY SERVICE
                                INSPECT. CLEAN. AND/OR REPLACE FILTERS AS NECESSARY
ACTION CODE    0318
SHOP CODE      3-020
                                AIR CONDITIONER. UNITARY
                                MONTHLY SERVICE
                                CHECK FREON IN SYSTEM BY SIGHT GLASS OR MANIFOLD GUAGES  CHECK
                                OIL IN COMPRESSOR CRANKCASE. OIL MUST SHOW 1/2 FULL   OIL COND
                                FAN MOTORS. MAKE SURE COILS ARE CLEAN   MAKE SURE FILTERS ARE
                                NOT PLUGGED   OIL MOTORS AS NECESSARY
ACTION CODE    0319
SHOP CODE      3-020
                                AIR CONDITIONER. UNITARY
                                ANNUAL SERVICE  (SPRING START UP)  2 HRS SERVICE PER UNIT
                                CLEAN CONDENSER AND EVAP  COILS AND BLOW OUT WITH NITROGEN
                                CLEAN AND OIL EVAP MOTORS AND FAN MOTORS  CLEAN COMPRESSOR
                                CONTROLS  START COMPRESSOR. CHECK FREON IN THE SYSTEM ADD
                                FREON AS NEEDED  CHECK COMPRESSOR CRANKCASE OIL  OIL MUST
                                SHOW 1/2 FULL IN SIGHT GLASS WITH COMPRESSOR RUNNING CHECK AND
                                ADJUST ALL SAFETY CONTROLS  LEAK TEST ENTIRE SYSTEM
ACTION CODE    0320
SHOP CODE      3-020
                                AIR CONDITIONER. UNITARY
                                ANNUAL SERVICE  (FALL SHUTDOWN - APPROX SEPT 30)
                                PUMP DOWN UNIT   DISCONNECT POWER TO CONDENSER
ACTION CODE    0321
SHOP CODE      3-020
                                ICE MAKER (CUBER)
                                MONTHLY SERVICE
                                CHECK WATER SUPPLY TO CUBER   CHECK FLOAT ASSEMBLY AND WATER
                                VALVE. KEEP FREE OF LIME DEPOSITS. CLEAN CONDENSING COILS. AND
                                OIL FAN MOTORS   KEEP COMPLETE CONDENSING UNIT WIPE CLEAN OF
                                ALL DIRT. LINT AND OIL
ACTION CODE    0400
SHOP CODE      3-006
                                BLOCK "U"
                                SEMI-ANNUAL SERVICE
                                REPAIR ANY DAMAGES DONE TO THE BLOCK "U"
                                CHECK OULETS. COVERS. CONDUITS. PANELBOADRS. ETC
ACTION CODE    0401
SHOP CODE      3-006
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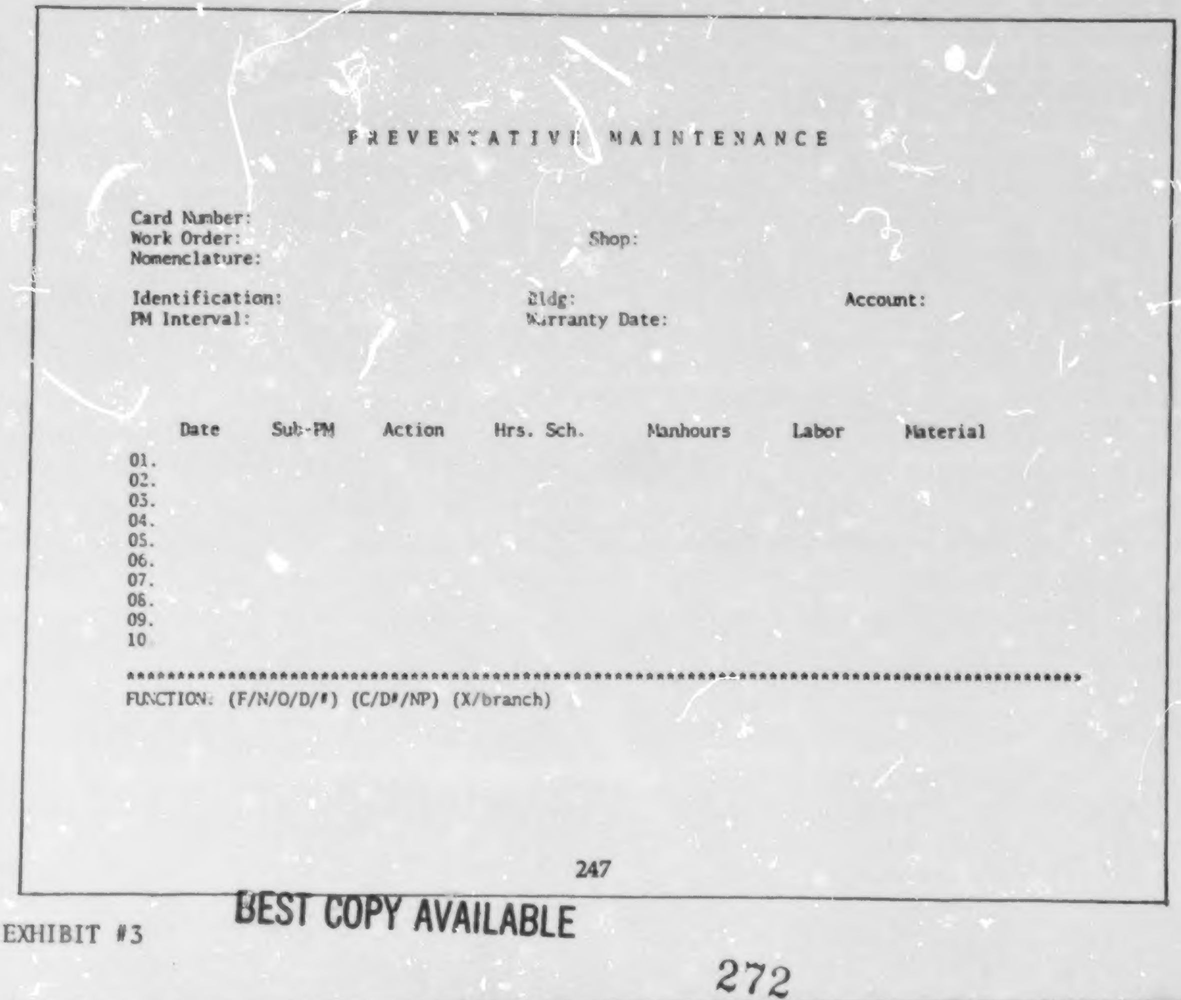
EXHIBIT #4



```
                  PREVENTATIVE MAINTENANCE

Card Number:
Work Order:                          Shop:
Nomenclature:

Identification:                      Bldg:                   Account:
PM Interval:                         Warranty Date:


     Date    Sub-PM    Action    Hrs. Sch.    Manhours    Labor    Material
01.
02.
03.
04.
05.
06.
07.
08.
09.
10
**********************************************************************************
FUNCTION: (F/N/O/D/#) (C/D#/NP) (X/branch)
```

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EXHIBIT #3

W.O. M105
SECTION : 5-017
PM SUBS :
PRIORITY
CARD # : 110141
ACCT # 1-08125
A.C # 0933
SCH DATE JANUARY
DATE [illegible]
REC. BY: FM
DEPT
BLDG ROOM EXT
ISSUED BY:
PROJECT LOCATION · BLDG 105 ROOM

SERIAL NUMBER: 697528GP

DESCRIPTION PUMP, CHILL WATER. 1 UNIT. BELL & GOSSETT 1531. 1-1/2B PUMPS.
SEMI-ANNUAL SERVICE.
LUBE PUMP AND MOTOR. CHECK SHAFT AND THRUST COLLARS. CHECK SLEEVE BEARINGS MECHANICAL SEAL, CIRCULATOR COUPLER. CHECK IMPELLER.

ESTIMATED	WORK DONE BY			COMMENTS:
H				
L				
M				
T				
	INIT	DATE	HRS	APPROVED BY: DATE:

EXHIBIT #5

```
PREVENTATIVE MAINTENANCE MASTER FILE                                                                  SHOP NUMBER IS 5-017

PAGE 415              DATE: 12 42:04  03 APR 1984

WONUM    CARD . DATE       ACTION HRS ECH     MAN        LABOR   MATERIAL                                 NOMENCLATURE
                           CODE              HOURS .      COST       COST
                         *  *        *     *        *          *
                03/01      0975        1.00      1.00      10.09       0.00
                04/01      0975        1.00
                05/01      0975        1.00
                06/01      0975        1.00
                07/01      0975        1.00      2.00      20.18       0.00
                08/01      0975        1.00      2.00      18.69       2.40
                09/01      0975        1.00      2.00      18.69       0.00
                10/01      0975        1.00      2.00      18.69       0.00
                11/01      0975        1.00      1.00       8.60       0.00
                12/01      0975        1.00      1.00       9.35       0.00
         ***
F105     110076 02/01      0978        2.00      2.00      18.69       0.00 IDENTIFICATION: NONE         FAN. SUPPLY (2)   TRANE
                                                                            BUILDING      : 105          CLIMATE CHANGER TYPE  17
                                                                            ACCOUNT NUMBER: 1-08125      U4D33982   10HP  1750 RPM
                                                                            PM INTERVAL   : SA           220/208V  3 PH   CENTURY
                                                                            WARRANTY DATE : 0            MOTOR. PART #6330779-01.
                08/01      0975        2.00
                09/01 P                          2.00      18.69       0.00
         ***
M105     110138 01/01      0983        1.00      1.00       8.16       0.00 IDENTIFICATION: NONE         PUMP, CONDENSER   #1234
                                                                            BUILDING      : 105          BELL & GOSSETT 1531   3121
                                                                            ACCOUNT NUMBER: 1-08125      SIZE 1-1/2 1.5 PH. 1725 RPM
                                                                            PM INTERVAL   : SA           200/208V  3 PH
                                                                            WARRANTY DATE : 0
                02/15 S
                03/01 P                          1.00       8.16       0.00
                07/01      0983        1.00      1.00       8.93       0.00
         ***
M105     110141 01/01      0983        0.50      1.00       8.16       0.00 IDENTIFICATION  697528GP     PUMP, CHILL WATER   1 UNIT
                                                                            BUILDING      : 105          BELL & GOSSETT 1531.  1-1/2B
                                                                            ACCOUNT NUMBER: 1-08125      B7-1/2BF   2 HP  1750 RPM
                                                                            PM INTERVAL   : YR           200/208V. 3 PH. MOTOR BELL &
                                                                            WARRANTY DATE : 0            GOSSETT.
                02/15 S
                03/01 P                          1.00       8.16       0.00
                08/31 S
                09/01 P                          4.00      30.64       0.00
         ***
L105     110144 01/01      0975        3.00      2.00      18.69       0.00 IDENTIFICATION: NONE         FILTER
                                                                            BUILDING      : 105
                                                                            ACCOUNT NUMBER: 1-08125
                                                                            PM INTERVAL   : MT
                                                                            WARRANTY DATE : 0
                02/01      0975        3.00      1.00       8.60       0.00
                03/01      0975        3.00      1.00      10.09       0.00
                04/01      0975        3.00
                05/01      0975        3.00
                06/01      0975        3.00
                07/01      0975        3.00      1.00       6.90       0.00
                08/01      0975        3.00      1.00       8.60       0.00
                09/01      0975        3.00      4.00      37.38       7.20
                10/01      0975        3.00      1.00      10.09       0.00
                11/01      0975        3.00      2.00      18.69       0.00
                12/01      0975        3.00      1.00      10.09       0.00
         ***
M105     110191 03/01      0980        3.00      2.00      13.30       0.00 IDENTIFICATION  NONE         TOWER COOLING
                                                                            BUILDING      : 105
                                                                            ACCOUNT NUMBER: 1-08125
                                                                            PM INTERVAL   : SA
                09/01      0980        3.00      1.00       6.90       0.00 WARRANTY DATE : 0
```

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EXHIBIT #6

UNIVERSITY

CAPITAL EQUIPMENT AND INVENTORY

Transaction Number.................

(1) Section.......................

(2) Building......................

(3) Room..........................

(4) Location Description

(5) Item Description

(6) Pur/Installation Year

(7) Life Expectancy..............

(8) Total Cost...................

(9) P.M. Card No.................

(10) Source of Funding............

FUNCTION: (F/N/O/D/H) (X/M)

EXHIBIT #7

UNIVERSITY

CAPITAL RENEWAL AND REPLACEMENT

Transaction Number................

(1) Building..................

(2) Room......................

(3) Location Description

(4) Project Description

(5) Site......................

(6) System....................

(7) Type......................

(8) Year To Be Completed

(9) Total Cost................

(10) Source of Fund...........

(11) Shop Code................

FUNCTION: (F/N/O/D/H) (X/M)

EXHIBIT #8

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PLANT OPERATIONS - CUSTODIAL STANDARDS - SPACE SURVEY

SPECIAL TASKS FORM

AREA 2 BLDG. NO. 015 RM. 321 TYPE* F CONGESTION** L DATE 8-8-83

	task code	amt.	annual freq.		task code	amt.	annual freq.
(1)	500	200	1	(9)			
(2)	501	200	1	(10)			
(3)	575	2	1	(11)			
(4)	576	2	1	(12)			
(5)				(13)			
(6)				(14)			
	dry clean code	amt.	wkly. freq.	(15)			
(8)				(16)			

SPECIAL TASKS

[illegible] FLOOR STRIPPING
[illegible] FLOOR REFINISHING
[illegible] STAIR STRIPPING & REFINISHING

[illegible] DRY CLEANING, 150-175 rpm.
[illegible] DRY CLEANING, 300-350 rpm.
[illegible] DRY CLEANING, 1000 rpm.

[illegible] CARPET SHAMPOOING-ROTARY EXTRACT
[illegible] CARPET SHAMPOOING-POWERED. EXTRACT

SPECIAL TASKS

575 FURNITURE, VINYL CHAIR
576 FURNITURE, FABRIC CHAIR
577 FURNITURE, TABLET ARMCHAIR
578 FURNITURE, STUDENT CHAIR & DESK

600 CHALKBOARD, THOROUGH CLEANING

625 RESTRM., PRESSURE SPRAY

700-999 UNIQUE SPECIAL TASKS

* TYPE

• classrm., lect.hall, aud., seminar rm., nursery
entrance
• lunch rm., vending area, lounge, kitchen
rm, recreational facilities
H • hall, foyer
L • lab, shop, studio, computer rm.
N • nursery
• office, recep. area, conf. rm., copy rm.
R • restrm., shower rm., dressing rm.
S • stairs, landings
V • elevator
X • storage
Z • custodial closet

** CONGESTION

L • light (hall)

M • medium (office)

H • heavy (fixed seat classroom)

X • extra heavy (mov. seat classr

JE (dc)/ FEB. 83

EXHIBIT #9

PLANT OPERATIONS - CUSTODIAL STANDARDS - SPACE SURVEY

REGULAR TASKS FORM

AREA ______ BLDG. NO. ______ RM. ______ TYPE* ______ CONGESTION** ______ DATE ______

	task code	amt.	wkly. freq.		task code	amt.	wkly. freq.		light code	amt.	annual freq.
(1)				(9)							
(2)				(10)							
(3)				(11)							
(4)				(12)					floor code	amt.	
(5)				(13)				(17)			
(6)				(14)				(18)			
(7)				(15)				(19)			
(8)				(16)				(20)			

REGULAR TASKS

001 OUTSIDE ENTRY
002 ENT. DOOR GLASS
003 ENT. MAT

025 DUSTMOP
026 VACUUM
027 DUST; SPOT CLEAN
028 GARB. CONTAINER

050 CIGARETTE URN
051 DRINKING FTN.

075 STAIRS, HARD
076 STAIRS, CARPET
077 ELEV. INSIDE
078 ELEV. OUTSIDE

REGULAR TASKS

100 CHALKBOARD
101 LAB SINK
102 PAPER TOWEL DISP.

125 VENDING, HALL
126 VENDING, ROOM

150 RESTROOM

175 LIGHTS, FLOUR.
176 LIGHTS, INCAN. [illegible]
177 LIGHTS, INCAN. COV.

200-499 UNIQUE REGULAR TASKS

FLOOR TYPES

A ASBESTOS TILE
B BRICK, QUARRY TILE
C CARPET
D CEMENT
E CORK
F LINOLEUM
G MASKAPADE
H PEDESTAL
I RUBBER
J TERRAZZO; MARBLE
K VINYL SHEET
L VINYL TILE
M WOOD

* TYPE

C • classrm., lect.hall, aud., seminar rm., nursery
E • entrance
F • lunch rm., vending area, lounge, kitchen
G • gym, recreational facilities
H • hall, foyer
L • lab, shop, studio, computer rm.
N • nursery
O • office, recep. area, conf. rm., copy rm.
R • restrm., shower rm., dressing rm.
S • stairs, landings
V • elevator
X • storage
Z • custodial closet

** CONGESTION

L • light (hall)

M • medium (office)

H • heavy (fixed seat classroom)

X • extra heavy (mov. seat classroom)

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REGULAR TASKS FOR BUILDING #  015
11:10:21   29 AUG 1983

AREA BLDC ROOM   ROOM CONGESTION  TASK.           TASK              AMOUNT  FREQ  MINUTES   MINUTES
     NO   CODE   TYPE             CODE            NAME              (UNITS) (WK)  PER UNIT  PER WEEK
                                        *                            *       *     *         *
  2  015 00321     F LIGHT        025   DUSTMOP                        200    3   0.0031     1.8600
                                  026   VACUUM                          54    5   0.0181     4.8870
                                  027   DUST: SPOT CLEAN               254    1   0.0028     0.7112
                                  028   GARB  CONTAINER                  1    5   0.3849     1.9245
                                  175   LIGHTS; FLUOR.                   1    1   0.0470     0.0470
                                  176   LIGHTS: INCAN  UNCOV             1    1   0.0194     0.0194
                                                                                          ----------
                                                                                             9.4491   *** TOTALS FOR ROOM NO. 00321

  2  015 00322     C X-HEAVY      026   VACUUM                         420    5   0.0216    45.3600
                                  027   DUST, SPOT CLEAN               420    1   0.0055     2.3100
                                  028   GARB  CONTAINER                  1    5   0.3591     1.7955
                                  100   CHALKBOARD                      64    5   0.0712    22.7840
                                  175   LIGHTS, FLUOR.                   4    1   0.0470     0.1880
                                                                                          ----------
                                                                                            72.4375   *** TOTALS FOR ROOM NO  00322

  2  015 00323     D MEDIUM       025   DUSTMOP                         99    3   0.0103     3.0591
                                  027   DUST, SPOT CLEAN                99    1   0.0136     1.3464
                                  028   GARB. CONTAINER                  1    5   0.2333     1.1665
                                  175   LICHTS; FLUOR.                   1    1   0.0470     0.0470
                                                                                          ----------
                                                                                             5.6190   *** TOTALS FOR ROOM NO  00323

  2  015 00324     L MEDIUM       025   DUSTMOP                        360    5   0.0103    18.5400
                                  175   LIGHTS; FLUOR.                   3    1   0.0470     0.1410
                                  177   LIGHTS; INCAN. COV.              4    1   0.0381     0.1524
                                                                                          ----------
                                                                                            18.9334   *** TOTALS FOR ROOM NO. 00324

  2  015 00325     D MEDIUM       026   VACUUM                         117    3   0.0138     4.8438
                                  027   DUST, SPOT CLEAN               117    1   0.0136     1.5912
                                  028   GARB  CONTAINER                  1    5   0.2333     1.1665
                                  175   LIGHTS; FLUOR.                   1    1   0.0470     0.0470
                                                                                          ----------
                                                                                             7.6485   *** TOTALS FOR ROOM NO. 00325

  2  015 00326     G LIGHT        025   DUSTMOP                       2448    5   0.0031    37.9440
                                  027   DUST; SPOT CLEAN              2448    1   0.0028     6.8544
                                  028   GARB  CONTAINER                  2    5   0.3849     3.8490
                                  177   LIGHTS, INCAN  COV.              2    1   0.0381     0.0762
                                                                                          ----------
                                                                                            48.7236   *** TOTALS FOR ROOM NO  00326
                                                                                          ----------
***** TOTAL FOR BUILDING  *****                                                           2583.4397
```

REP. LIST. CUSTODIAL. REG BLDG

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EXHIBIT #10

VEHICLE SCREEN

Vehicle-Number: 1) Plan: 5) License:
2) Make: 3) Model: 4) Year: 7) Account:
6) Serial Number:

Start Odometer: Date: Last Odometer: Date:

Year-To-Date	Life-To-Date
Materials:	Materials:
Labor Hours:	Labor Hours:
Total Maint. Cost:	Total Maint. Cost:
Cost per Mile:	Cost per Mile:
Gasoline Used:	Gasoline Used:
Average MPG:	Average MPG:
Total Gas Cost:	Total Gas Cost:
Total Cost:	Total Cost:

FUNCTION:

EXHIBIT #11

K E Y S   S Y S T E M

HOOK #:
BUILDING:
ROOM:
DESCRIPTION:

TYPE OF KEY:
AUTHORIZED SIGNATURE:

	ISSUE NAME	SOC. SEC. NUM.	DEPARTMENT	DATE
(1)				
(2)				
(3)				
(4)				
(5)				
(6)				
(7)				
(8)				
(9)				
(10)				

****

FUNCTION: (F/N/O/D/H) (#/C#/P/B/PB) (DP/M/X)
TOTAL PAGES:

EXHIBIT #12

An Organized Department Means Motivation

George B. Wright
Service Engineering Associates, Inc.

A. "Motivation is the discovery of some need, emotion, or impulse that is strong enough to culminate in action."

1. It is possible to know a lot about motivation and still find it difficult to apply what you know.
2. Everyone is a distinct individual and what motivates one person may have no effect on the other.

B. An organized department means motivation.

1. Your department must have a complete program which gives simultaneous action in many areas in order for you to have motivated employees.
2. We need to find out: "Who is your employee?"
3. All types of people are involved.
4. Most of us suffer with a poor image--low status.
5. We need to develop a motivational climate.
6. Create a positive feeling of expectancy between you, your people, and your whole facility.

C. Fair and equitable treatment.

1. No playing favorites; live within the policies of your company.
2. Develop a clear organizational picture.
3. Display a schedule of disciplinary action. Let the employees know what to expect if they break the rules.
4. Equal opportunity for all.
5. Practice the Four "F"s: Fair, Firm, Friendly & Factual.

D. The three questions.

1. Is he or she obeying the rules?
2. Is he or she doing the job?
3. Is he or she interfering with others?

E. Recognition.

1. Use of names in the correct way. Have name badges for each of your employees showing full name and title.
2. Recognize a Worker of the Month.
3. Uniforms for all department employees.

4. Titles: Group Leaders, Senior Aide, Maintainer, Supervisor, Foreman, Project Supervisor, etc. Avoid old titles such as Janitor, Maid, Laborer, Floater, etc.
5. Give service pins. Example: Service pin awards for 1, 5, 10, 15, 20 years of service.
6. Meet top executives.
7. Employment anniversary letters.
8. Quarterly evaluations--feedback on job performance.

F. The tools for the job.

1. Size, type, quality and quantity.
2. Avoid equipment sharing.
3. Good looking equipment.
4. Chemicals--do not run out; use quality products.

G. Job assignments.

1. Easy, safe methods.
2. A reasonable day's work.
3. Balance work loads among your employees.
4. Use area assignments--rotate if worker desires.
5. Establish a Project and Relief team.

H. Training Program--A continual activity.

1. It has been said that every individual has to be completely retrained at least four times in a lifetime.
2. Orientation.
3. Classroom training--give certificates.
4. On-the-job training.

I. Get their participation.

1. Custodial closet design.
2. Equipment and chemicals selection.
3. Uniforms.
4. Scheduling and assignments.

J. Leadership from you.

1. Set the example of hard work.
2. Organize, deputize, and supervise.
3. Stand up for your people.

Creative Funding of Energy Conservation Projects

by:
Thomas Chen
&
Eugene A. Simko
Daverman Facilities Management

Abstract

The energy crisis is not behind us. Instead, it has joined the fiscal crisis at many APPA institutions in a wicked spiral whose result is fewer dollars available each year for the operation and maintenance of the physical plant. Escalating energy costs demand larger portions of shrinking budgets; budgets too tight to fund energy retrofits.

In an effort to break this spiral a team consisting of architects/engineers, accountants, financial consultants, lawyers and legislators have designed a package of services and financing which enables cash starved institutions to formulate and execute a comprehensive energy management plan at below market rates of interest. The financial instruments making this possible can be either a purchase contract backed by the credit of the institution or a lease contract in which the lessor retains ownership of the equipment. At the end of the lease contract, the lessor often donates the equipment to the institution. During the life of the contracts the institution realizes a positive cash flow while making payments from avoided energy or maintenance costs. Many states do not yet allow public institutions to use these types of financial vehicles. The question of the legality of these arrangements has been resolved by some state legislatures including Arizona, California, Connecticut, Michigan, and Ohio.

The benefits of a comprehensive energy management package are multitude: Design and construction contracts are stimulated; the nation's energy dependence is decreased; and most importantly, the fiscal spiral at APPA institutions is broken.

Introduction

While it may be unnecessary to convince the people responsible for budgeting the operations and maintenance of large physical plants that energy conservation remains a pressing imperative now and into the foreseeable future, we need to be armed with a knowledge of the factors that influence energy price trends. This knowledge will be an aid in not only anticipating price trends, but, will enable you to persuade others within your organizations of the need for immediate and effective energy management programs.

Energy trends. The last decade has taught every inhabitant of this planet Earth not only the importance of energy to our daily lives, but, many other relationships of energy to political and economic issues. We have seen the apparently limitless power of a cartel (OPEC) humbled in abeyance to market forces. The price elasticity of demand for energy products has been estimated. In general, as energy prices rise 1.0 percent, demand can be expected to fall 0.4 percent. In 1972, a barrel of oil traded at $1.50. That price climbed to a peak of $34.00 in 1979 until reduced demand motivated a fall to current levels of $29.00 per barrel. Unfortunately, the good news of recent price declines is overshadowed by the magnitude of long term increases. (Refer to Exhibits 1 and 2) The truly bad news is that the relative efficiency of our energy consuming systems has in no way kept pace with energy price escalations requiring larger percentages of physical plant operating budgets to be devoted to energy. In aggregate, higher education spent over $3.2 billion in FY 1981/82 and over $3.5 billion, or 6% of the general education budget, in FY 1982/83 which enjoyed an unusually mild winter. Recent price declines should not be allowed to lull us into conservation complacency. The energy crisis has in no way ended.

While the current energy market is considered by many to be stable and expected to increase only in recognition of general price inflation, we also learned in the past decade that the oil balance is quite sensitive to external forces and events. Standard Oil of California reported in its 1982 World Energy Outlook that oil supply can be easily shocked by political events (such as the current Iran/Iraq war) and stated, "The future will certainly witness upsets similar to those of the recent past." The sensitivity of oil prices to political events should caution us to take energy price forecasts with a grain of salt.

Over the last decade we have also seen the impact of economic cycles upon energy prices. It has been estimated that a 1.0 percent increase in GNP boosts energy demand by 1.1 percent. Increased demand leads to escalating prices. Moderate growth is forecast through 2000 for the world economy (Refer to Exhibit 3). Conversely, economic recession results in decreased demand and stable or declining prices. Free world demand for oil has decreased 13 percent since 1979 which can be attributed not only to two major recessions, but, to the permanent effects of conservation programs, structural economic switching to service economies and fuel switching from oil products (Refer to Exhibit 4).

What then is the energy forecast? Given a stable world, oil and gas prices will escalate at parity with inflation. Given the politically and economically unstable world in which we live, brace yourselves for an upward roller coaster ride. Given a scenario of increasing energy costs, what then is your mission as professional physical plant administrators? In a word: CONSERVE.

The real problem. Let's probe further into the realm of economics. Energy is a line item which competes for operations and maintenance funds with the other line items in your budget. How can the increasing hunger of the energy budget line be satisfied? The funding resources of your institutions are finite. In many cases, O & M budgets are shrinking in response to fiscal austerity. Because higher education also has a price elasticity of demand you cannot simply pass along energy price increases. We all know that conservation programs require capital investment in order to realize the benefits of avoiding future energy costs. Auditing and engineering fees and retrofit costs simply have no source of internal funding at many institutions. Shrinking budgets require your ingenuity to arrest the theft of funds from other line items to pay for escalating energy bills and capital investment requirements as well.

These pressures have forced professionals to manage their physical plants more rationally. We have discovered the cost effectiveness of deferred and preventive maintenance programs. We are beginning to discover creative financing. If internal funds are not available to temper the energy budget's appetite, we must look to the external financial markets for capital investment funds. As professionals, we must educate ourselves in the pros and cons of the variety of financial vehicles available in order to select the most appropriate to our situation. We must also educate ourselves to be able to evaluate program alternatives and design the optimal energy conservation package.

We at Daverman Facilities Management began our energy conservation education in 1972 when oil sold for $1.50/barrel. We quickly learned three facts: (1) Most physical plants had been designed with no concern for energy consumption thus revealing tremendous potential for this country to achieve its goal of energy independence; (2) Most institutions did not have internal capital for conservation investment; and (3) Energy conservation saves money which can be used to fund conservation programs. The challenge, then, was how to apply the stream of anticipated avoided costs at time zero in order to realize those avoided costs. The immediately obvious solution was to borrow in order to invest in the energy conservation program retiring the debt from future avoided energy costs.

Any source or method of financing other than those capital budgeting avenues which you regularly access, can be thought of as "creative financing." Indeed, we must be creative when faced with an overwhelming problem - energy costs - and no traditional solutions. We at Daverman were creative in the mid-70's after talking with countless physical plant administrators and learning of the energy motivated fiscal dilemma. Not only were institutions faced with escalating energy costs and no internal funds available to remedy the situation, but, we found that state legislation barred many institutions from accessing the private financial markets. In order to truly be a solution to the energy dilemma we were compelled to blaze a trail on a state by state basis that public institutions could follow to the markets.

Trail blazing. Briefly, we found it necessary to form a multi-disciplined team consisting of financial, accounting, legal, legislative and energy management expertise to comprehensively provide the vehicles necessary for escape from the energy quagmire. The team cooperated in, first of all, drafting and persuading the passage of enabling legislation at the state level. This legislation made it possible for public institutions to pay for a comprehensive energy improvement construction program out of energy costs avoided through the program. Notes are paid from general operating sources which are concurrently relieved of a greater amount in energy costs. In short, the institution can implement an energy program without additional burden to its cash flow. The only "trick" to positive cash flow financing is that energy and maintenance costs avoided must exceed the note's amortization schedule.

Requirements

Legal. Public institutions must live within legally defined debt limitations and cannot incur multi-year liabilities (except bonded liabilities). In many cases state statutes must be enacted to allow institutions to: (1) Establish or expand a debt ceiling; (2) Incur debt through vehicles other than bond issues; (3) Provide incentives for investors; or (4) Specify that energy improvements qualify for the benefits of leasing or borrowing. Daverman has at this writing opened three states to avenues of creative financing. It is not an easy process but the benefits to state fiscal coffers often sell legislation on its own merits.

Technical. Any decision to repay current debt from anticipated cost avoidance bears an element of risk. While there can easily be predicted an upward trend, the future of energy prices is uncertain. Since cash flow projections should account for energy price escalation, a conservative, informed estimate of that escalation is prudent. Of further importance is the estimation of anticipated cost avoidance. The engineer's endorsement on your energy program is evaluated by many lending institutions just as carefully as your credit worthiness. Having the audit performed by a successful, experienced engineering firm can often result in lower interest rates on the note and the difference between "just another report" and the implementation of a propitious energy program.

Financial. Energy management is a dollars and cents game. In projecting future cash flows all the pertinent variables - current consumption, projected consumption, price escalation, interest rates, capital required - must be estimated in sufficient accuracy to allow the assessment of a realistic cash flow projection. Experience must be consulted in packaging the energy management program. While short and long payback measures can be combined to produce an average program payback which is feasible in positive cash flow terms, the astute energy manager recognizes the performance interaction of individual measures and lengthens his average payback estimate accordingly.

Vehicles. A variety of creative financing vehicles exist today which include Building Reserve Funds, Bond Pools, Shared Savings, Scallop Plans, Municipal Leases, Municipal Bonds, General Obligation Bonds and Limited Tax General Obligation (LTGO) Notes. This paper will not attempt to discuss the pros and cons of each of these instruments. Our experience has taught us that the tax exempt status, quick availability and long tradition of usage recommends Municipal or LTGO Notes.

Municipal Bonds and Notes enjoy a tax exempt status which can generally provide lower interest rates than conventional corporate business borrowing and can be used to finance property (insulated glass, building insulation, etc.) improvements. Municipal leases, however, can generally be used to finance equipment *only*, e.g. EMS, boilers, etc. Program financing can be arranged in amounts ranging from $100,000.00 to several million dollars. All program "soft costs" including audit and design fees, bond counsel and financial consulting expenses can be included in the financial package. In order to qualify for a Municpal Lease or Note the institution generally must be a political subdivision as described in Section 103(a)(1) of the Internal Revenue Code of 1954, as amended. Private institutions could only participate through a state educational facilities authority or similar organization.* The terms of a Municipal Bond or Note must be structured to meet a state's legal restrictions regarding debt restrictions, particularly in regard to limiting your institutions's obligation to making payments to a single fiscal period. This requirement is met through the inclusion of a "non-appropriation" clause which does not relieve the responsibility of making future payments, but, does satisfy legal restrictions by making them a current expense subject to regular appropriation.* Each state's financing requirements may vary.

The LTGO Note enjoys the tax exempt status of Municipal Leasing at interest rates generally below prime. A 7 year LTGO Note can finance an energy program with an average payback of 4.5 years (a 10 year note can finance an average 6.5 year payback) and provide positive cash flow, depending upon prevailing interest and energy escalation rates. In our experience we have packaged non-energy capital improvements, e.g. deferred maintenance or bus purchases with high performing energy measures using LTGO Notes. Finally, our experience with LTGO Notes has been that of quick access to funds seeing money deposited in the institution's account within 30 days of signing the agreement; well in advance of the first draw on the funds allowing the institution to realize the bonus of short term interest accumulation.

The Daverman Program

Since 1972 Daverman has built a solid reputation in facilities programming and has a long list of energy management and maintenance management projects in its resume. Now that we have added the creative financing dimension to the services we provide, a typical comprehensive energy management program can be described as follows.

---

*The Association of Physical Plant Administrators Energy Task Force, Document 30, "Municipal Lease Financing for Public College and Univeristy Energy Efficiency Projects," 1983, Washinton, D.C.

Preliminary audit. After a preliminary meeting with physical plant management to obtain energy records and subjective impressions of conservation opportunities, Daverman performs a walk-through review of the facilities. If opportunities for a cost effective energy conservation program exist, Daverman enters into an agreement with the client in which the firm commits to propose a schedule of improvements and financing plan which can generate annual energy cost avoidance greater than the client's projected annual payments under the proposed contract. The proposal is generally submitted within 45 days of signing the agreement. If Daverman fails to submit such a proposal which outlines a positive cash flow approach to finance the program based upon projected energy cost avoidance, and a guaranteed financing, the client is not charged for proposal development costs. If the proposal is submitted on time and conforms to the conditions outlined above, the client must proceed with the project or pay the costs of proposal development.

Energy audit and plan. Once the proposal is accepted Daverman undertakes a full audit of the facilities and prepares a complete technical and financial report. The report includes analysis of the audit results, historical energy usage patterns, description of capital improvements and revisions to maintenance procedures. Also included is a program financing pro forma and cash flow statement.

If the client approves the proposal, Daverman will prepare construction documents for purchasing the specified equipment, bidding and observing its installation and other construction related services, arranging financing, and specifying and bidding an ongoing maintenance contract. In compliance with state regulations on government financing and purchasing, Daverman bids out every aspect of the work: purchased equipment, installation and construction, and ongoing maintenance. Daverman places program financing with the organization offering to write the lowest interest rate.

Financing The financial arrangement Daverman offers is either through a lease or purchase agreement. To the extent that the lessor retains ownership rights to the equipment for the term of the contract, it is a lease. However, in other important aspects - the scope of the project costs financed, the repayment schedule, the relatively minor role of tax benefits in the stream of returns to the investors - the arrangement resembles a construction project loan more closely than a lease.

Over the term of a lease contract, the lessor retains ownership of the equipment. The amount of the principal attributable to depreciable assets and to equipment for which tax credits are available will vary depending upon the technical conditions at the site. The term of the lease is usually seven years or less. At the end of the contract, the lessor often donates the equipment to the client. In the case of a purchase contract, the note is backed by the full faith and credit of the institution.

Daverman has sought and obtained legal opinion that the contractural arrangements described above constitute full faith and credit obligations of municipalities, community colleges, universities or school districts in Michigan. The tax exempt status of the interest payments has enabled Daverman to obtain interest rates lower than the prevailing prime rate for its larger clients.

A case study of the Muskegon School District was presented at APPA '84.

Homework

Obviously, as a professional physical plant administrator you desire to and should be intimately involved in any program which would alter the operation or maintenance of your physical plant. The following is a checklist of issues you must resolve before embarking upon a creatively funded energy management program at your institution. Touching all the bases in their proper order will ensure that your energy program is a home run.

1. Determine the existence of or the ceiling for your debt capacity.
2. Determine your institution's credit rating.
3. Identify your in-house energy management expertise.
4. Determine the energy history of the facilities - collect utility bills, document meter locations and implemented energy conservation measures.
5. Document known energy conservation opportunities.
6. Determine anticipated local energy cost escalation by fuel.
7. Familiarize yourself with your institution's normal capital budgeting proccess.
    a. What monies or creative financing vehicles are available?
    b. When are budget requests due and how long is the process?
    c. Who must approve requests?
    d. Where will repayment funds come from - the utlity budget line or a separate budget line?
    e. Why are policies and procedures as they are?
8. Determine which creative financing vehicles are currently available and what steps can be taken to open the opportunity for other vehicles.
    a. Define legal or institutional barriers - you may want to consult a bond attorney.
    b. Learn the institution's procedures for using creative financing vehicles.
    c. Determine project acceptance criteria applicable to each vehicle, e.g. simple payback, return on investment, positive cash flow.

Conclusion

The cost of energy will continue to increase at APPA institutions. Forecasters agree that price increases will at least be at parity with inflation. Further, the potential for future oil shocks is great due to world political and economic instability. The charge to professional physical plant administrators is: Conserve. Given the fiscal context of most APPA institutions many opportunities to conserve must be deferred unless funding can be obtained for energy programs from private financial markets. Once institutional and legal barriers to access these markets are removed a carefully designed energy program can be implemented under a positive cash flow scenario. Consultants, such as Daverman Facilities Management, can bring their successful experience in energy management planning, retrofit design, construction administration, maintenance management and financial planning to bear on the success of your program.

The energy crisis is not behind us which emphasizes our responsibility to avail ourselves of currently viable solutions to our individual and collective energy problems.

Arabian Light Official Crude Oil Prices $/Barrel F.O.B.

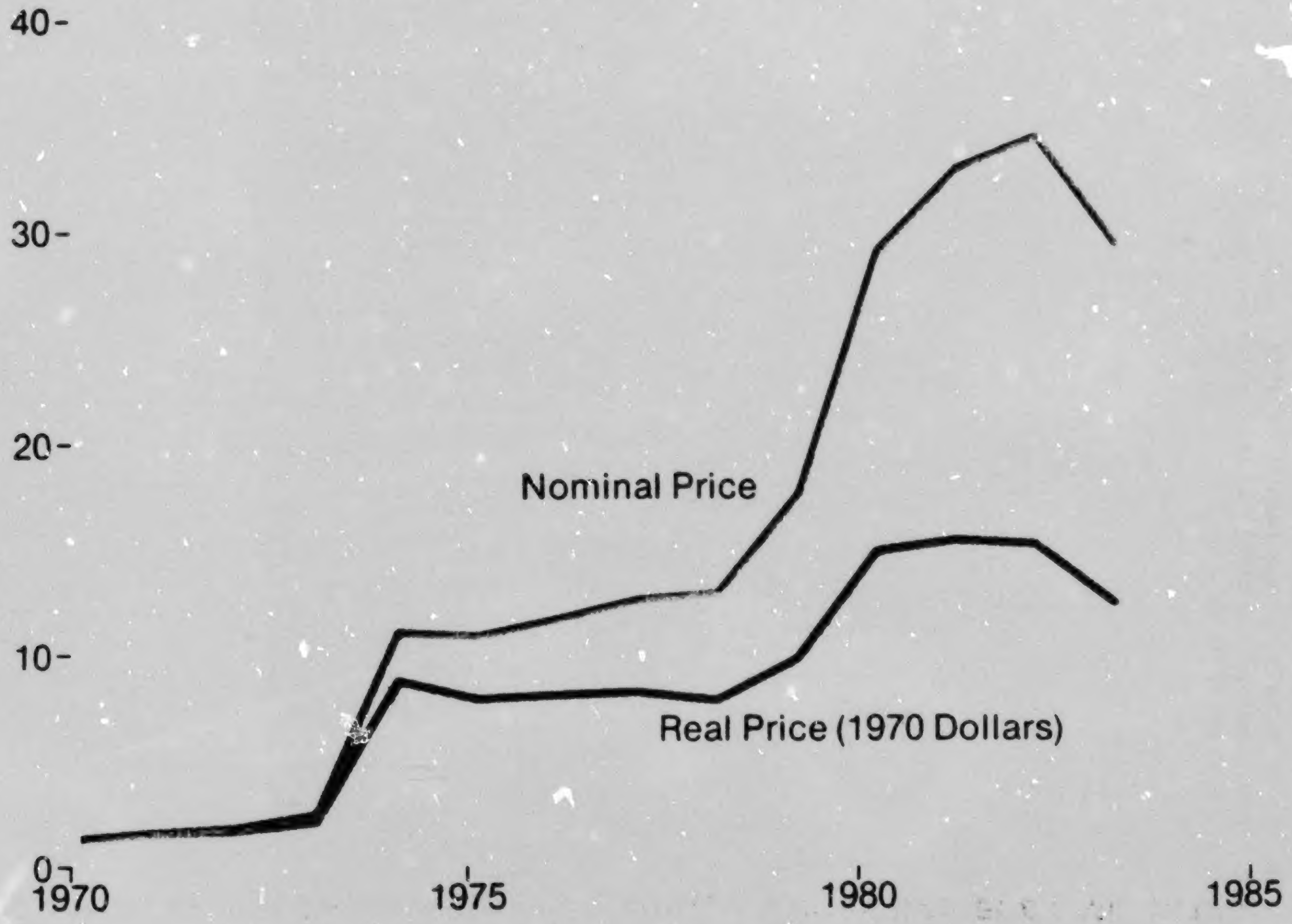
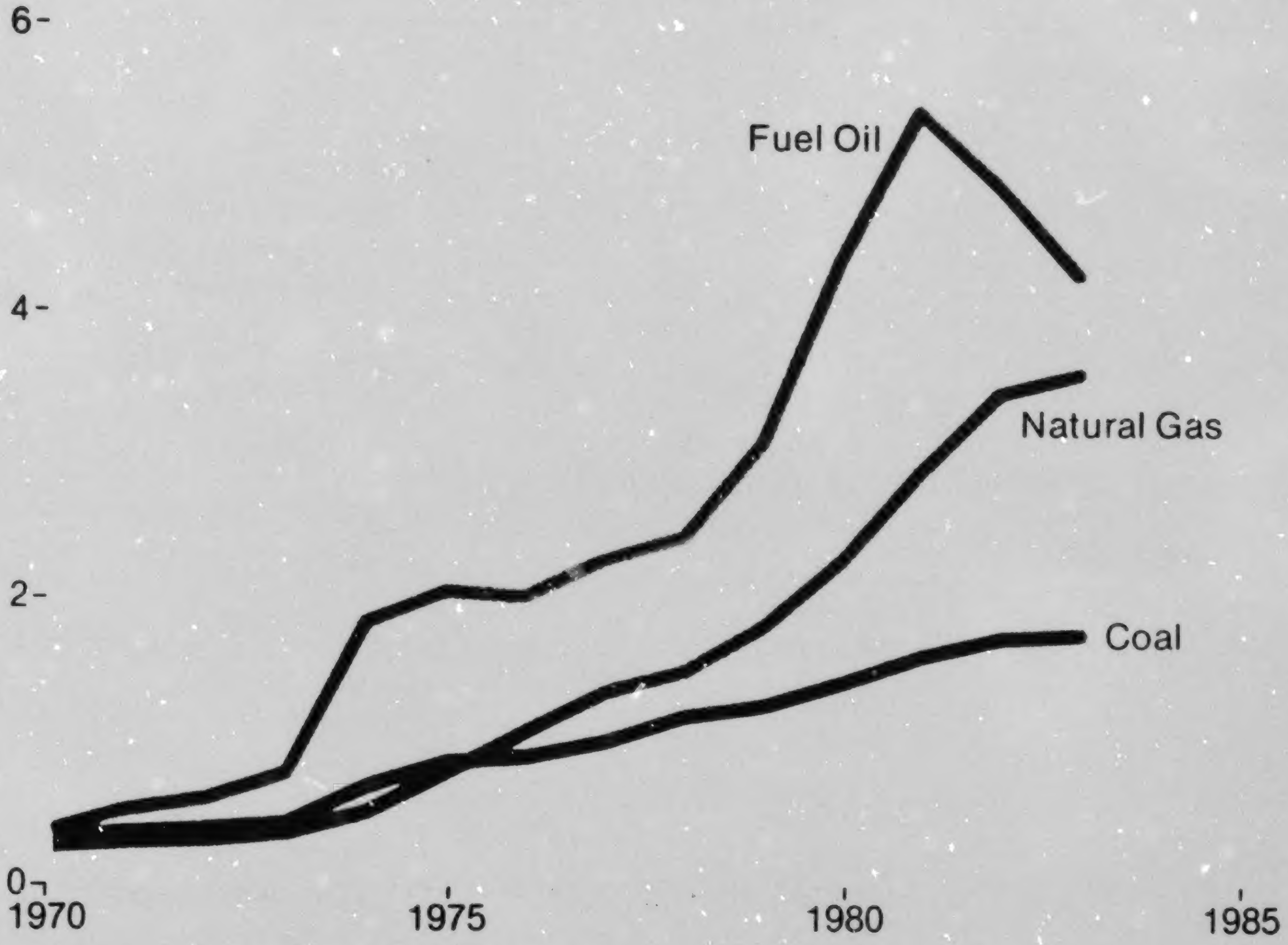


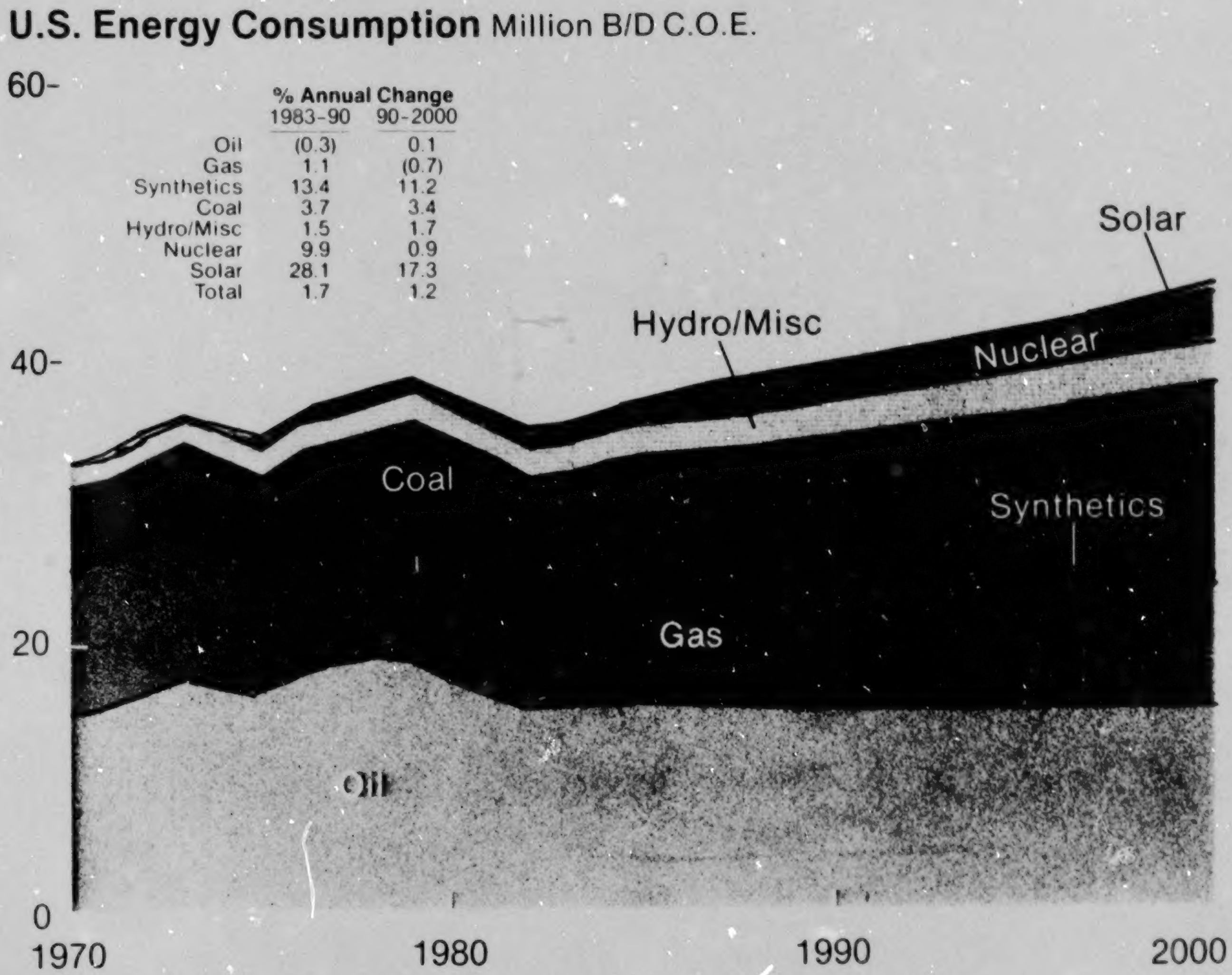
EXHIBIT 1

Cost of Fuels for Electric Utilities, United States Average $/Million Btu



Real GNP Growth — Percent Annual Change

					Forecast			
	Pre-1974 Trend	1974–79	1981	1982	1983	1984	1990 Over 1980	2000 Over 1990
U.S.	3.5	2.8	1.9	−1.7	3	5	3	2½
Canada	5.0	3.2	3.1	−5.0	3	5	3	2½
W. Europe	4.5	2.5	−0.1	1.0	2	3	2½	3
Japan	8.5	4.0	3.8	3.0	4	4½	4	4½
Sino-Soviet	5.5	4.0	1.5	3.5	3½	3½	3½	3
Other Areas	6.5	5.0	1.0	1.5	4	5	4½	5½
World	5.0	3.5	1.3	1.1	3	4	3½	3½



U.S. Energy Consumption Million B/D C.O.E.

	% Annual Change 1983-90	 90-2000
Oil	(0.3)	0.1
Gas	1.1	(0.7)
Synthetics	13.4	11.2
Coal	3.7	3.4
Hydro/Misc	1.5	1.7
Nuclear	9.9	0.9
Solar	28.1	17.3
Total	1.7	1.2

EXHIBIT 4

Performance Evaluation Made (Almost) Easy

By Phyllis Rossiter Forbes
University of New Hampshire

For many managers, performance evaluation is an annual duty that is dreaded and often avoided. For the average or better employee, it is often just a pat on the head, followed up by a form letter for the personnel file. Or it's a next-to-useless form, devised centuries ago by a committee appointed by the president or chancellor, which is mechanically completed by the employee and the supervisor and then placed in the personnel file. The feedback provided to the employee (and we're talking about the average or better employee, remember) is useless. The goals being judged, if, indeed, any were set, are so vague and broadly stated that they may bear little resemblance in fact to what was actually done (or not done). Often what is covered in a performance evaluation is recent, with little sense of time (or history) attached to it and little constructive feedback on what strengths can be further developed and what needs to be done to improve weak areas. Or, little attention is given to how the individual has developed (changed) in the last twelve months. In other words, feedback on an individual's performance can be used to motivate and seldom is because it isn't done accurately or systematically.

For the underachieving employee (or that group which can politely be called "entrenched marginal performers"), performance evaluation may reduce itself to mutual recriminations, grievances and, generally, a great investment in lost time, a classic stand-off. "Entrenched marginal performers" have invested years in beating the system and we supervisors have aided and abetted them in that activity. Indeed, were job standards set, and employees held to those standards, the "entrenched marginal performer" would not exist as an employee category. S/he would either have improved, switched jobs or left our employ years ago.

Avoiding the situations outlined above is relatively easy, provided one begins the process at the beginning, namely, at the beginning of the evaluation period. The purpose of this paper will be to describe a method of setting performance standards or goals, reviewing them periodically for the purpose of coaching the employee, and giving feedback in a positive and growth-inducing way. Before I begin, however, I want to place before you three facts:

1. As line managers, we are responsible for managing ourselves, our relationships with others and the basic tasks of our jobs.

2. To do this, we must set job standards and enable others to carry them out. It is not our responsibility to do them ourselves!

3. Job performance problems are usually rooted in unclear expectations and the supervisor is at fault.

To begin our discussion of performance evaluation, I will begin at the beginning, with the issue of job standards or goals. I prefer to use the term "job (or performance) standards" because the term "goal" has become so hackneyed as to be meaningless. The term "performance standard" does not have quite the ambiguous and subtle meanings and is my preferred phrase. What are performance standards? Quite simply, they define the job. They follow from the job description, deal with the requirements of the job (not the person), and establish the conditions that will exist when the job is done (or at least after some period of time). They are measurable, specific, achievable, impersonal and they focus on results. All of this sounds absolutely self-evident except that it is almost never done. If standards are set, they are couched in the language of "goals" and are vague, ambiguous and very tough to evaluate, especially with our "entrenched marginal performers".

Please note, also, that performance standards should follow from the job description. This can be a problem if we have not looked at our job descriptions lately. Many job descriptions exist solely for the purpose of making personnel bureaucracies feel needed and useful and bear little resemblance to what an individual may actually be doing. So the manager may have to revise the job description to reflect the actual responsibilities. This takes time, it's true, but many line managers are quite surprised by the lack of fit between what employees are actually doing and what job descriptions say they are doing. For those of you who are fortunate enough to have union shops or rigid classification systems, I would not suggest trying to change the official job descriptions. Instead, try to work up descriptions of what they are actually doing and what you want them to do and sit down and negotiate a description that approaches reality as it is (or as you would like to see it.)

Job standards deal with the requirements of the job and not the person. While I would be the first to advocate allowing an employee to shape a job to his/her talents, this will only work once some irreduceable minimum has been met. If that minimum cannot be met, regardless of the reason, you've got the wrong person in the job. One of our jobs as managers may be to help some of our employees out of their jobs and into others or out of the organization completely. If done with a measure of kindness, this is both realistic and best for both parties (the employee and the organization). In establishing the conditions that will exist when the job is done, or after a specific period of time, performance standards will provide answers to the questions: How do we know when the job is done? How well is the job to be done?

Having stated the importance of job standards and what they are, I want to hasten to say that setting standards is not easy, it is time-consuming and people resist. But it is worth the effort. Do not be led astray by the employee who tells you s/he can't be expected to meet certain standards (or cannot set them for his/her own people) because higher education doesn't pay enough. Tell him/her that none of us is paid what we're worth, but that does not excuse us from performing. I want to offer you a few guidelines which I have adapted from an article by George S. Odiorne,[1] which appeared in the March, 1981 issue of Training and Development Journal:

1. A performance standard is a statement of output, not activity. In other words, where are you going, not what will you do along the way.

2. Performance standards must be explicit so that when people are trying to agree whether or not it was met, they can find easy agreement. That means it must describe the behavior (or result) you expect to see and the level of performance you expect (fifty percent, ninety percent, one hundred percent). A performance standard must have a time frame or it will not be a commitment. This does not necessarily mean that failing to meet a performance standard within the time frame connotes failure. It does mean that all parties should examine the reason for that omission.

3. Make your performance standards of ascending difficulty. Start with the ones where the output numbers are easiest to identify and move to the standards where innovation and breaking new ground will mean more ambituous standards. This is, in some way, a contradiction of my caveat about being explicit, but I do it for two reasons. One, it gives an employee a sense of accomplishment to look down a set of performance standards and see immediately ones that are (or have been) easy to accomplish. (It also gives the supervisor a sense of how to proceed to the more difficult standards). Second, the most difficult goals will stretch the imagination of both the employee and the supervisor, forcing them to break ground and create new situations which can then be defined. This is how both organizations and people grow and as supervisors, we ought to be encouraging and enabling it.

4. Certain kinds of performance standards will have to be defined within a range of outcomes. This is a corollary to the guideline stated above and is used more frequently within certain areas which are difficult to define (traffic management, facilities planning, public relations) and with upper level managers.

5. Good performance standards create the resources to produce them. Having gone to the trouble of quantifying where you want to go and what it takes to get there often creates the resources needed. It is very difficult to say "no" to a well-thought-out idea.

6. Performance standards begin at the top. The reasons for the organization's existence flow down; ways to achieve those ends flow up. One can't exist without the other.

8. Every performance standard accepted means that another has been rejected. Resources are limited, so in order to make an informed choice, one must have examined all the options. A good manager knows what options were rejected and why.

9. Don't stress the obvious. For real growth to occur, people must

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[1] George S. Odiorne, "Guides for Successful Managerial Coal Setting", Training and Development Journal, March 1981, pp. 9-10.

study the obvious from a new angle and find ways of improving on it, rather than projecting an incremental and minor change, or, worse, repeating last year.

10. Performance standards should always be set in face-to-face negotiation and not by memoranda and letters alone. Such discussions may involve bargaining, resolving disagreements, and getting commitments to change behavior, none of which can be done by correspondence. After the standards are set, it is appropriate and necessary for the supervisor to transmit them in writing with a summary letter.

11. All other things being equal, try participative standard setting first. People seem to expect a voice these days and I believe should be allowed to participate unless you suspect some serious footdragging. In those rare cases, don't let the principle of participative management deter you from imposing goals. You are responsible ultimately for getting the job done.

12. Many performance standards are hard to attain. Some won't be achieved, either because of unforeseen circumstances or because people weren't rigorous enough in choosing the standards. This does not mean the process is of little value, only that it is difficult.

I have spent a great deal of time on setting standards because it is vital to the entire process of performance evaluation. Performance evaluation is a process, not a single event. It is spread over time, and it develops and changes. To be most useful, it must be on-going, open and candid. Open communication and explicit feedback stated in behavioral terms are vital. Essentially, the supervisor must create a "critical-incident" file. This is necessary because no one can remember one year's work (or even six months') without notes. Also, mistakes may linger in memory longer than small successes, so it is necessary to keep notes during the course of the year. These may include handwritten notes, letters of commendation, major reports, etc. Caring about people's work means caring enough to criticize constructively. I have a few guidelines for giving feedback.

1. Use "I" statements. You can only speak for yourself, not others. In this case, as the supervisor, it is your observations that are important.

2. If there is a problem, do not let it simmer, but wait at least twenty-four hours to get the anger out. This allows you to analyse the problem and enables you to deal with it more objectively.

3. Make behavioral observations - tell it as it is - be descriptive. Focus on performance, give details, keep it simple.

4. Don't overtalk - let the silences sit. Nervousness often makes a chatterbox of the supervisor. Silence allows your statement to sink in and does not divert attention from the issue at hand.

5. Use statements such as:

   "do more of......."
   "do less of......"
   "keep doing......."

6. It is O.K. to have notes. This helps you be specific and it tells the employee you have done your homework. Be as specific and as timely as possible.

7. Get agreement/benchmarks for improvement. State these in behavioral terms and with a definite time limit. If someone continually fails to improve, move him/her out.

8. When appropriate, discuss strengths. People need to be told what they are doing well and managers tend not to do it often enough.

9. Context and situation are important, as are timing and privacy. Watch your tone of voice - give specific, matter-of-fact feedback and avoid being a "punishing parent". Be sure your verbal and non-verbal behaviors match. Don't send mixed messages.

10. Avoid any reference to "bad attitude". This is a total stand-off. Describe the behaviors (or patterns of behavior) which the individual is exhibiting. (This is especially true for substance abusers and I'll say more about this later).

11. Only give feedback on things that can be changed.

12. Look at the person. Eye contact is vital, assertive and guarantees that you are more likely to be heard.

Having set mutual performance standards and provided feedback along the way, the annual review becomes a less onerous task. Indeed, while I would not call a good review an easy task, most of the work has been done throughhout the year. The supervisor gathers and reviews the written record (job description, performance standards and the incident file). There should be no surprises, no new ground plowed. The review should be scheduled at a time when both individuals are at their best and any supervisory expectations regarding preparation should be made known ahead of time. Typically, I ask the individual to describe his/her accomplishments, what was not done (and why) and any constraints I (or the organization) may have created. I allow the employee to begin and then I add to the employee's points and I do it by describing specific behaviors, results and products. I like to concentrate on enhancing strengths and helping the employee develop a road map for improving weak areas. I then follow up with a letter which summarizes the discussion and requests the employee to respond (preferably in writing) if s/he takes issue with anything.

Needless to say, all of this takes time and energy. Writing good performance standards which are expressed in measurable terms is not easy and it takes practice. Selling the process to your employees may not be easy, either. But the advantages are many:

1. The employee will know exactly what is expected and in what time frame.

2. Because performance standards are explicit, arguments over whether or not they have been met will be reduced (one hopes) to a minimum.

3. Because expectations are in writing, all parties can refer to them periodically to refresh memories and/or to rewrite/revise them.

4. Because they are in writing and ascend in difficulty, most (if not all) employees can easily see their progress.

5. Written performance standards can serve as a checklist for the supervisor when evaluation time rolls around.

6. Written standards allow us to move in on the "entrenched marginal performer" and the substance abuser, with a minimum of wasted time spent in grievances and recriminations.

A short digression regarding these problem employees is appropriate. Both groups (the entrenched marginal performers and the substance abusers) are masters at the art of diverting your attention from the issue at hand, which is their performance. Having written standards in explicit behavioral terms, reflecting back to these employees their behavior patterns in specific detail and tying those patterns to their failure to attain the agreed-upon standards is absolutely essential to solving the problem - either improving performance or removing the employee. In these instances, the more detail the better. Stay away from references to attitude or to drugs/alcohol. Translate the abuse into terms which describe how s/he is not doing the job. If you have done your homework, it won't be necessarily easy, but it will be possible.

In summary, I want to emphasize that clear expectations, specific feedback and support for the employee are absolutely essential for a workable performance evaluation system. The result (better performance) is worth the time and effort. When our employees perform well, it makes them feel good and us look good.

Comprehensive Planning for Employee Training and Development

by William D. Middleton, P.E.
University of Virginia

Introduction

Few things that we do as physical plant managers could be more important than our task of training and development for the people in our organizations. An effective continuing program of employee training and development is simply an essential element of any successful physical plant program.

There are many other elements to a successful physical plant program, too, but all of them depend upon the same basic ingredient if they are going to work properly, and that's skilled, experienced people. Surely we can all agree on this. It's obvious, it's self-evident, but what do we do about it?

Rarely do the skilled, experienced maintenance employees we need walk in off the street, and there just aren't any schools to train people for the kinds of work we do in physical plant. All of us have to do pretty much the same thing, and that's train and develop our own skilled maintenance workers, supervisors, and managers.

Just about all of us devote substantial amounts of time and resources of our organizations to training and development, but how well do we plan the use of the time and resources that we expend on training? Most of us, I'm afraid, do it badly.

How do we decide who to train, what to train them in, and how to train them?

All too frequently our training programs are made up largely of "ad hoc" decisions based upon training availability, rather than a comprehensive plan based upon specific training objectives and designed to obtain maximum effectiveness from our training expenditures.

Planning for Training

To plan effectively for training we must, first of all, have well-defined objectives:

- Obviously, our primary training objective must be to develop needed technical and professional skills and needed supervisory and management skills in our organizations.

- An important secondary objective is to provide development opportunities for individual career advancement within the organization, and to develop well-qualified supervisors and managers for the future.

- We must establish who we need to train.

- We must determine what training they need.

- We must decide how we can best train them.

Let's look more closely at each of these.

Training and Development Objectives

Our objectives will vary significantly between different categories or groups of employees. We can identify five distinct groups of employees, each of which has different training and development needs:

Entry Level Employees. Basic familiarization training is required to assist new employees in becoming effective members of the organization. Formal indoctrination training program should include such topics as:

- University or college employee policies and procedures, benefit programs, disciplinary program, and the like.

- Departmental employee policies and procedures, training and advancement opportunities, and the like.

- Safety program requirements.

- University or college and departmental familiarization tours.

Journeyman Level Employees. Training efforts at the level of productive employees should be primarily directed at the acquisition or enhancement of craft skills.

- Sub-journeyman training through apprenticeship or other training programs should develop the skills and experience required to attain journeyman status.

- Journeyman training should be directed primarily at maintaining basic skills of the trade, developing new skills required by technical advances within the trade, and maintaining code familiarity.

First-line Supervisory Level Employees. For employees at the foreman or other equivalent first-line supervisory levels, training needs are primarily in area of supervisory and management responsibilities including:

- Basic supervisory and management training.
- Safety program training.
- Technical training needed to maintain an adequate knowledge of current developments in their trade.

Middle Management Level Employees. For superintendents or other middle-management supervisors and professional employees, primary training needs include:

- Advanced management development training.
- Advanced professional and technical training.

Senior Management Level Employees. For the top level of departmental management, broad management development training is required in such areas as:

- Planning and budgeting.
- Physical plant programs and systems management.
- Internal university or college organization and responsibilities, policies, and procedures.
- External local and state government organization and relationships to the college and university.

Training Availability

Having determined what kinds of training are required for an effective program, we need to determine where the necessary training is available. There are four principal areas of training availability:

Departmental Programs.

While a wide variety of training is usually available from external resources, we usually will find that in order to provide the comprehensive program of training that we need, a significant amount of training will have to be developed within the department. These will usually include such programs as these:

- New employee orientation.

- Crafts apprenticeship programs.

- Crafts certification programs.

- Basic employee skills training and development.

- Safety training.

- Management development training for subjects that are unique to physical plant.

University or College Programs.

Most institutions typically offer through their personnel and training organization a variety of general supervisory and management development training and training in specific skills which are needed on an institution-wide basis. A well-developed program, in larger institutions at least, might typically offer training and development opportunities such as these:

- Short courses in the fundamentals of supervision, university or college organization, equal opportunity, employee relations, or supervision of new employees.

- Workshops in human relations for supervisors, personnel management, or institution specific supervisory information.

- Basic data processing or word processing training.

- General management development training programs.

- Secretarial and clerical development.

Outside Programs.

Significant training and development opportunities are available through programs offered by a variety of outside institutions, associations, and commercial organizations. Some of the most important ones for physical plant managers include:

- The APPA Institute for Facilities Management.

- The annual meetings and seminars conducted by APPA and other related professional associations.

- Special programs and seminars offered by other educational institutions and commercial organizations.

Off-Duty Study.

A great many of our training objectives, particularly for individual employee development and advancement, can be met by encouraging off-duty study programs. Some of the best sources of off-duty training include:

- Community colleges.
- Vocational-technical schools.
- Correspondence study courses available from APPA and other organizations.

Organizing for Training

We have briefly reviewed some of the basic objectives of a training and development program for different categories of employees, as well as the several potential sources of support to a program. Now let's consider how we organize an effective training and development program.

Departmental Training Plan. Basic guidance for a program should come from a departmental plan which should establish or identify departmental training and development objectives, policy and procedure, training availability, and should assign responsibilities.

Training Committee. A training committee made up of senior departmental managers can be an important adjunct to an effective training and development program. An important task of the committee should be to provide continuing review and oversight of departmental training programs, identifying needed changes and improvements, as well as new requirements for training emphasis. The committee can also plan a program of training courses developed and offered at the departmental level.

Supporting Training Plans. While the departmental training plan provides overall guidance, each component of the department must also develop its own plan identifying its specific training and development needs. Finally, supervisors within the organization must establish with each employee reporting to them individual training objectives and planning. Effective completion of these supporting plans is essential to a really successful training and development program. These plans are where we identify our specific training needs and develop a plan for training that will best meet these needs within our available resources, both for the organization and for the individual employee. With our planned training thus identified, we can determine the best available training resources and program our training accordingly.

Training Records. An individual record of training should be maintained for each employee.

Conclusion

As senior physical plant managers, we must all regard training and development as one of our most essential tasks. Whatever else we do, it may not be of much value unless we have sufficient numbers of skilled people available to perform the work of our organizations. And our organizations won't have much of a future if we aren't providing opportunities and incentives for our best and brightest people to stay with us and to become the highly-qualified leaders we will need tomorrow.

I hope that my brief observations today will be of some help to each of you in organizing and planning for this essential task in a way that you can both afford and that will give you the results you need.

Deferred Maintenance
A Case Study for Funding

By Bruce R. Toro, P.E.
Daverman Facilities Management
and
Gordon Muir
Stanford University

Abstract

Deferred maintenance is a cancer on APPA facilities estimated at more than $35 billion in 1979. Establishing deferred maintenance requirements is not a new concept, and their programming has recently emerged as central to transforming a strategic maintenance concept into an operational maintenance program. Unfortunately, administrators usually shy away from funding "another study," and physical plants do not have the manpower resources to commit to a systematic identification and quantification of deferred maintenance.

Using accepted building valuation techniques, operation and maintenance personnel established an annual reinvestment value of the facility. A mathematical model establishes an investment range which, if funded, would turn around the deterioration of university assets. The planned maintenance program is the vehicle for achieving this goal. Once university officials are pursuaded that reinvestment in existing facilities is the way to preserve and extend the useful life of the facilities, a systematic method of identifying, costing, and reporting these deficiencies must be developed. This method allows analysis of costs by building system, trade, and priority. A micro-computer allows sorting of data for management analysis and decision. Once funded, the report serves as work orders to the craft shops.

None of the technology of planned maintenance programming is new or complicated. There is, however, creativity required in showing university administrators that funding deferred maintenance is a sound investment and that a "study" of this nature can be used to specifically document facility requirements; and after funding, it can be used as a management tool for increasing productivity.

Introduction

A comprehensive approach to facilities management requires good management techniques, funding support and consistent attention to the following ten concerns.[1]

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[1] Taken from: New Directions for Higher Education, Edited by H.H. Kaiser, Jossey-Bass, Inc. 1980

1. Goals and Priorities
    - Land Use
    - Enrollments
    - Facilities

2. Facilities
    - Inventory
    - Condition

3. Management
    - Practices and Procedures

4. Space Utilization

5. Capital Programs

6. Deferred Maintenance

7. Preventive Maintenance

8. Energy Conservation

9. Environmental Quality Health and Safety

10. Accessibility for the Handicapped

This dynamic program must be conducted on a cycle which considers the following:

First, identification of facility and system requirements that:

1. Must be retained and maintained indefinitely.

2. Must be maintained in order to continue use.

3. Have been identified for replacement.

4. Must be modified.

5. Must be constructed.

Second, phasing of work to satisfy requirements in the most timely fashion. This involves consideration of program priorities, extent of facility deterioration, season, etc.

Third, conversion of work requirements into resource requirements, in terms of manpower, materials, equipment and contractor projects.

Fourth, continuous updating of programs to respond to changing requirements, work accomplishments, changes in availability of resources or unforeseen conditions.

The implementation of a comprehensive program will often generate a substantial number of facility projects which can be accomplished either through contractor or in-house resources.

Our company was called upon by Stanford University to assist in addressing their Deferred Maintenance and Preventive Maintenance as input to their Planned Maintenance Program (PMP). The initial study of sixteen buildings evaluated the following building components.

- Architectural
- Civil
- Structural
- Mechanical
- Electrical
- Roofs

Stanford had conducted previous studies and, therefore, excluded the following items from our area of responsibility. The facility survey dealt with maintenance issues and requirements and evaluated the electrical, mechanical, structural and architectural components of the facility. The survey does not address the following items which are addressed by other programs:

- Energy Conservation
- Elevators
- Custodial
- Lab Equipment
- Department Owned Equipment
- Fire Protection
- Alarm Systems
- Site Utility Systems
- Illumination Levels
- Code Violations
- Furnishings

Conduct of Survey

General: The inspections were made by teams of Engineers, Architects and Technicians experienced in mechanical, electrical and architectural building systems. The team first reviewed all drawings and interviewed the O&M shop personnel to thoroughly familiarize themselves with the facility. They next interviewed the building managers, to obtain a different perspective of the buildings. This was followed by a comprehensive field inspection, preparation of field notes and a preliminary field report. This preliminary report was again discussed with O&M shop personnel. After this information interchange, cost estimates were prepared for each noted deficiency. This data was then processed on a Hewlett Packard 3000 Computer by Stanford O&M and final reports were prepared.

Approach: The survey consisted of a field phase (data collection and project identification) and an office phase (preparation of estimates and data documentation) on each building surveyed. It is essential that each identified deficiency be described in sufficient detail to provide realistic cost estimates. Data required includes quantities, sizes of equipment, materials, etc. The description, "Replace Steam Trap" is adequate, however, a better description would be "Replace three steam traps, Bell & Gossett, 15 psig, 1" pipe, reinsulate." Complete information is essential to comprehensive and accurate analysis and reporting. The office phase of the project was accomplished within fourteen days of completion of the inspection phase of the sixteen buildings. Incomplete data collection would require wasteful back-tracking to recover information. The field survey was performed by Daverman Facilities Management -- an international group of consulting Engineers and Architects. All data processing and resulting reports were prepared by Operations and Maintenance (O&M), Stanford University.

The field inspection was primarily visual but supplemented with instrumentation when necessary. Minimal hand tools were required - hammer, screwdrivers, pliers, adjustable wrenches, flashlights, measuring tapes, camera, etc. - for access to building components allowing accurate diagnosis of condition. If the visual inspection indicated that there was a major problem requiring an in-depth study/inspection/analysis, this was noted on the inspection form and the condition described sc that an engineering fee could be determined leading to a budget figure foi repairs.

Note that the inspection was non-destructive. Plaster ceilings are not removed to inspect the condition of piping, conduits, etc. However, lay-in suspended ceiling tile can be lifted as required.

Interface with building users and maintenance personnel: The Project Manager met with the Building Manager of each building to review past problems of a maintenance origin. He then briefed team members on these problems and sent his notes to the office for possible inclusion in the final building profile. The Project Manager and team members were then available for a week-ending meeting with university shop supervisors to discuss the findings for all buildings surveyed that week.

Stanford University provided past maintenance records held by their Operations and Maintenance Department. These records were made available to us in the form of a draft building profile. The building profile is a narrative summary of the facility inventory. While such records provide a history of problems, and form a basis for inspection, our investigation was not based solely on these records. Existing and potential maintenance and repair projects were visually identified during the field inspection.

Technical Issues

The reports PMP 310R and PMP 200R provide cost totals for Classes I, III, IV and V deficiency classes. The Preventive Maintenance Inspection (PMI) requirements (Class II) were not included in the summary totals because of the following basic difference in the type of cost:

Class I, III, IV, V - One Time Cost (Deferred Maintenance)
Class II - Annual Recurring Cost (Preventive Maintenance)

The Preventive Maintenance Program maintains the building systems in a sound operational condition after they have been repaired by correcting the Class I, III, IV or V deficiencies.

Definitions: The following is a Classification of Maintenance and Code Requirements which were used in assigning project priorities.

Class 1 - Prevent loss of life or property: Refers to a maintenance oriented deficiency which requires immediate correction to protect and preserve health or prevent loss of property. (For example: "Safety on hot water heater inoperative." or "No power on fire alarm system.")

Class 2 - Preventive maintenance/inspection requirements (PMI): Involves service requirements and frequency of performance needed for all systems under the PMI program. (For example: "Loose or worn belts, noisy bearings." or "Empty oil fittings, excess water in air compressor receiver.").

Class 3 - Non-deferrable mainteannce: Highlights maintenance deficiencies which, if not corrected within twelve months, might lead to costly physical damage. This includes the following types of deficiencies: a) Continued deterioration which would result in the loss of irreplaceable portions of the structure or interruption to the service of support systems; b) Continued deterioration which could destroy items of significant historical or monetary value; c) Elimination of conditions which lead to a waste of energy. Examples include: Leaking door or window-weatherstripping; roof or water leaks; leaking faucets or valves; missing steam pipe insulation; clean, pack, adjust and calibrate primary CW and heating valve.

Class 4 - Deferrable maintenance: Refers to maintenance deficiencies which, if not corrected within twenty-four months, will deteriorate into a Class 3 condition. Examples include identify and label control voltage source, motor control center; repair intake plenum lining to prevent further deterioration; install hinge on discharge access panel.

Class 5 - Aesthetic improvement: Some maintenance deficiencies require correction in order to improve the aesthetic conditions of the facility. Examples include: paint wall vicinity of light switch; provide splash behind drinking fountain to protect plaster finish; seal hairline concrete crack; remove (paint out) toilet room graffiti; replace door push plates; clean distribution panel cabinet and repaint; replace carpeting.

Class 6 - Code requirements - non-maintenance issues: Certain identified deficiencies require correction to meet current code requirements. These deficiencies should only be recorded if they fall in Class 1 or if a Class 3 or 4 item is also a code violation. Examples include; remove departmental combustible materials stored in electrical vault (N.E.C. required work space); replace open type front panels on Motor Control Center (N.E.C. required protection of live buss).

Activity identification listings (ID)

ID #	Type Work/Craft
11	Interior lighting/relamping
12	Electric power system
13	Exterior painting
14	Interior painting
15	Roofs and drains
16	Plumbing
17	Heat, ventilation and air conditioning
18	Steam systems
19	Elevators
20	Fire protection systems
21	Carpentry
22	Locksmithing and security
23	Floor covering
24	Glazing
29	Miscellaneous building maintenance and repair
32	Contract custodial services
33	Building pest control
34	Trash dispoal

Shop identification numbers. (Supplied by Stanford University.)

Forms: Task Screen Work Sheet. All data collected shall be entered on the Task Screen Work Sheet. The following are detailed instructions for completing that form (refer to Exhibit 1).

1. Location - Quad and Building number; for example - 07-410.

2. Multiple - If job involves two or more crafts, enter "Y"; if only one craft, leave blank.

3. Deficiency Class - Enter numerical code according to previous definition.

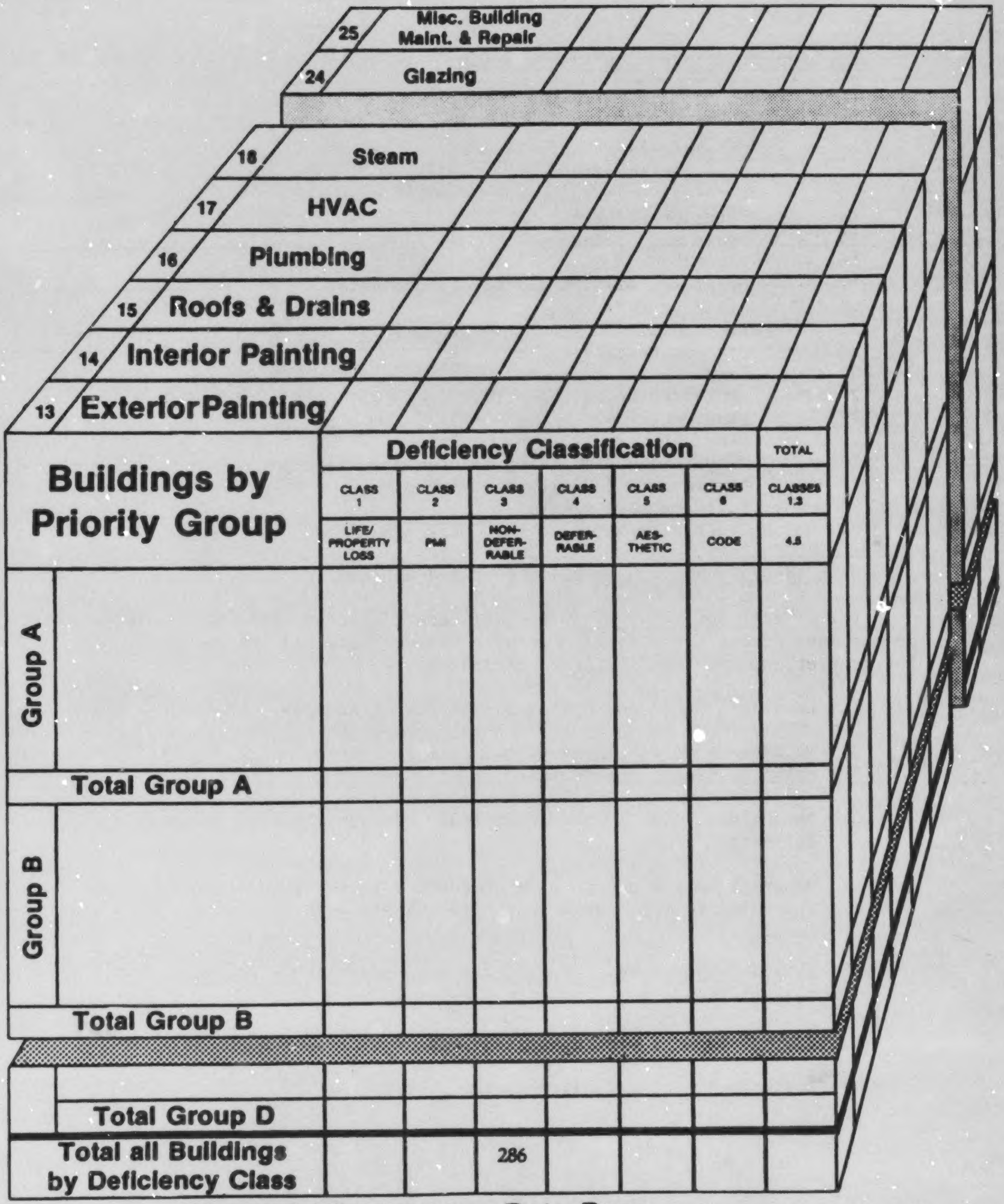
4. Description - Indicate room number and short title limited to spaces shown (26 characters); for example - RM 162: repaint door.

5. Date - Month/Day/Year of inspection - 04/15/83 Surveyor - Initial (4 max.)

6. Craft - Type of work/craft required.

7. Activity ID - Two digit number.

Exhibit 1



Buildings by Priority Group	Deficiency Classification						TOTAL
	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASSES 1-3
	LIFE/ PROPERTY LOSS	PMI	NON-DEFERRABLE	DEFERRABLE	AESTHETIC	CODE	4-5
Group A							
Total Group A							
Group B							
Total Group B							
Total Group D							
Total all Buildings by Deficiency Class			286				

Planned Maintenance Data Base

TASK SCREEN WORK SHEET

EXHIBIT 1A

LOCATION	MULTIPLE	DEFICIENCY CLASS	SPG REF.
NOTE #1	NOTE #2	NOTE #3	

DESCRIPTION	SURV DATE	SURVEYOR
NOTE #4	NOTE #5	NOTE #5

CRAFT NOTE #6 RATE

NOTE #11 COSTS

ACT ID.	SHOP	QUANTITY	UNITS	LABOR HRS	LABOR	MATERIAL	TOTAL
NOTE #7	NOTE #8	NOTE #9	NOTE #9	NOTE #10			

DESCRIPTION: NOTE #12

CRAFT RATE

COSTS

ACT ID.	SHOP	QUANTITY	UNITS	LABOR HRS	LABOR	MATERIAL	TOTAL

DESCRIPTION:

CRAFT RATE

COSTS

ACT ID.	SHOP	QUANTITY	UNITS	LABOR HRS	LABOR	MATERIAL	TOTAL

DESCRIPTION:

NOTES:

NOTE #13

EST DATE:

BY:

MATERIALS	QUANT	COST
NOTE #14		

8. Shop - ID numbers as supplied by Stanford.

9. Quantity - Amount of work items; for example - Int. paint 2000 units - SF, CF, EA, etc. up to five characters.

10. Labor Hours - Fill in if known otherwise leave blank for estimator.

11. Costs - Leave blank for estimator.

12. Description - Give detailed description and locations of work. Note: the next two sections pertain to the above information for additional crafts. Fill in if multiple craft.

13. Notes - Provide information to assist estimator, sketch if needed, add photos, if any. Continue on back of sheet.

14. Materials - Identify major items involved in project. If you have more than three crafts use an additional page.

Forms: mechanical - electrical equipment survey form. This form was provided by Stanford University. The form was not necessarily current and was corrected where changes were noted. The back of the form was used for comments concerning the condition of equipment. However, any project concerning the equipment was entered on a Task Screen Work Sheet.

Care was taken to write projects only for equipment which Stanford University Operations and Maintenance was responsible to maintain and to avoid pieces of equipment in mechanical rooms and spaces which were departmental maintenance responsibility. University personnel identified these items. If an equipment form was missing, either the equipment was not inventoried, added after inventory or was departmental. We determined which. Projects were written only for maintained equipment and not for departmental equipment.

Inspections sometimes required replacement of a portion of a system or an entire system. The securing, performing and reactivating of that system was coordinated with, and performed by, university personnel. Inspections performed under these conditions were expedited to minimize interruption of university operations. Under no circumstances did team personnel start or stop equipment.

Projects beyond visual inspection. In most instances, team members were able to determine the project scope in the course of the inspection. However, there were occasions when a project required an in-depth study/analysis/design in order to correct an observed or projected deficiency. Because of this, it was not possible to completely fill out the Task Screen Form Work Sheet in the field. The surveyor described the problem completely and the actions needed to correct the problem so that study/design costs and an estimated project budget could be determined. Design deficiencies or related problems were noted where obvious. However, the intent of the PMP is to categroize, prioritize and schedule maintenance tasks. Therefore, design related problems may not be completely corrected by the PMP.

The heading of the task screen form was completed with the short title, STUDY, PROJECT. The remainder of the form was completed with additional notes and other information to assist the estimator.

Example: Suppose the occupants indicated the building was cold. The inspection indicated that all components were adequately maintained and operational. A lack of heating coil capacity was suspected. We then recommended that an analysis of building requirements vs. coil capacity be made as a study project.

Facility Survey

The building survey, which is outlined in this report, identifies, quantifies and prioritizes the maintenance requirements for each building. The operation and maintenance needs of the facility are identified by task and then detailed in relation to man hours, labor cost and material cost. The survey is one of the steps in the Planned Maintenance Program (PMP) for transforming a strategic maintenance concept into an operational maintenance program. Other steps include the ranking of all campus facilities, classifying each task according to specific categories (see classifications below), entering the task information into the PMP data base, producing reports to review the survey results and working with senior management to decide which tasks should be accomplished. The goal of the PMP is to curb the deterioration of university assets, and restore and maintain each facility in an operational condition. In order to address the urgency of needed repairs, each deficiency (task) identified in this study is classified in one of the following categories:

I Prevent Loss of Life or Property

II Preventive Maintenance/Inspection (PMI)

III Non-Deferrable Maintenance

IV Deferrable Maintenance

V Aesthetic Improvements

In this report, you will find the results of the survey for Herrin Hall. The survey results are summarized as follows:

Report PMP 301R - Total cost of identified maintenance requirements broken down by craft and trade, and totaled by deficiency class.

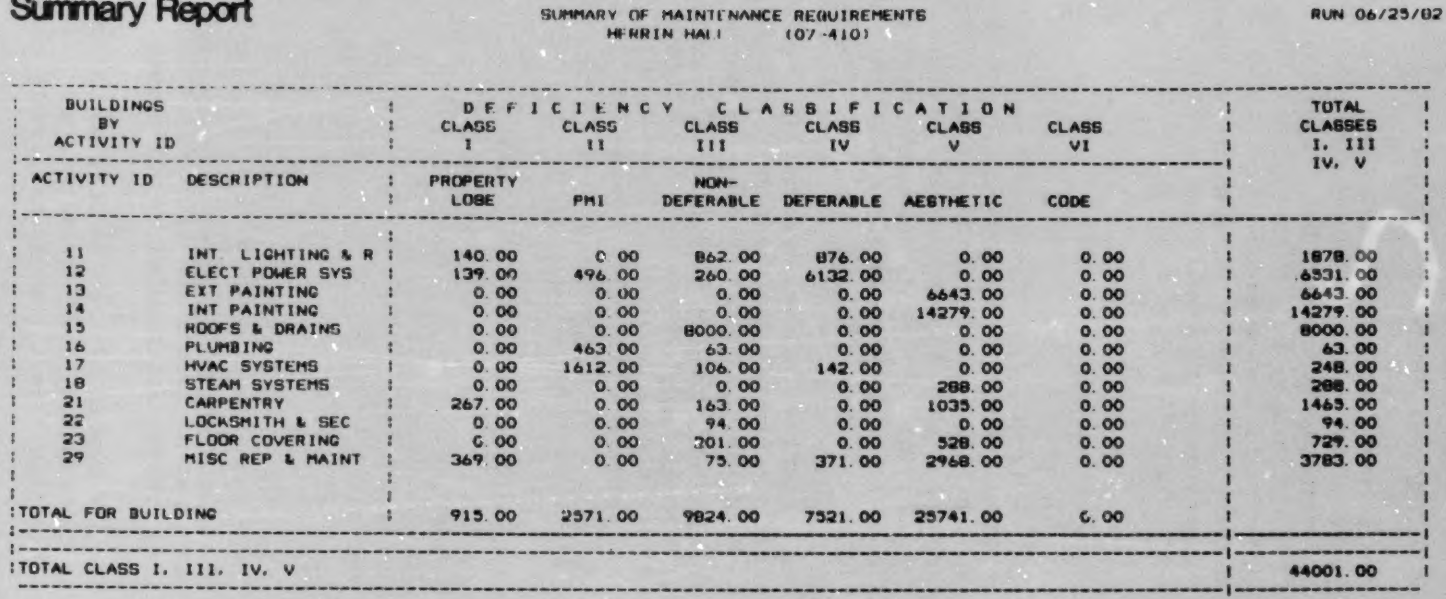
Report PMP 200R - Detailed report of each identified maintenance requirement including description, cost estimates, and craft and trade designation. This report is sorted by deficiency class.

(Please see Exhibit 2 for a visual aid to these reports).

BEST COPY AVAILABLE

Exhibit 2

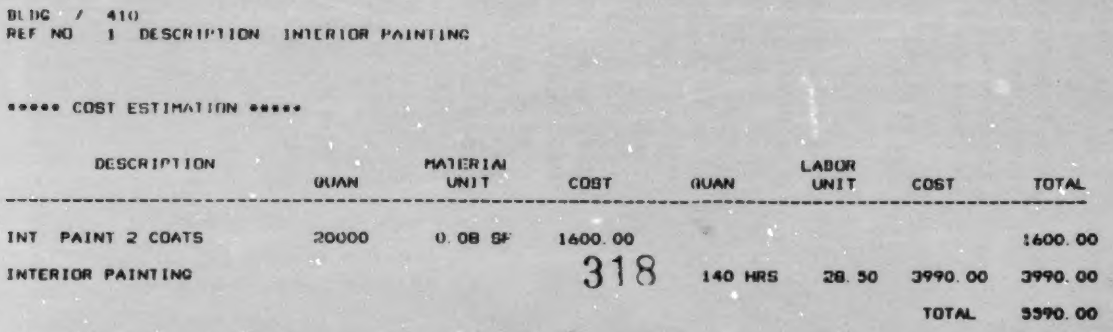
Summary Report



```
                               SUMMARY OF MAINTENANCE REQUIREMENTS                                  RUN 06/25/82
                                     HERRIN HALL      (07-410)

-------------------------------------------------------------------------------------------------------------------
:    BUILDINGS                      :    D E F I C I E N C Y    C L A S S I F I C A T I O N    :      TOTAL      !
:       BY                          :    CLASS      CLASS      CLASS      CLASS      CLASS      CLASS    :     CLASSES     :
:   ACTIVITY ID                     :      I          II        III         IV         V          VI     :     I, III      :
:-----------------------------------------------------------------------------------------------------------!     IV, V       !
: ACTIVITY ID   DESCRIPTION         :  PROPERTY                NON-                                      :                 !
:                                   :    LOSS       PMI     DEFERABLE  DEFERABLE  AESTHETIC    CODE      !                 !
:-----------------------------------------------------------------------------------------------------------------------------!
:                                   :                                                                    !                 :
:     11          INT  LIGHTING & R :    140.00      0.00     862.00     876.00       0.00       0.00    !     1878.00     :
:     12          ELECT POWER SYS   :    139.00    496.00     260.00    6132.00       0.00       0.00    !    .6531.00     :
:     13          EXT PAINTING      :      0.00      0.00       0.00       0.00    6643.00       0.00    !     6643.00     :
:     14          INT PAINTING      :      0.00      0.00       0.00       0.00   14279.00       0.00    !    14279.00     :
:     15          ROOFS & DRAINS    :      0.00      0.00    8000.00       0.00       0.00       0.00    !     8000.00     !
:     16          PLUMBING          :      0.00    463.00      63.00       0.00       0.00       0.00    !       63.00     :
:     17          HVAC SYSTEMS      :      0.00   1612.00     106.00     142.00       0.00       0.00    !      248.00     !
:     18          STEAM SYSTEMS     :      0.00      0.00       0.00       0.00     288.00       0.00    !      288.00     :
:     21          CARPENTRY         :    267.00      0.00     163.00       0.00    1035.00       0.00    !     1465.00     !
:     22          LOCKSMITH & SEC   :      0.00      0.00      94.00       0.00       0.00       0.00    !       94.00     !
:     23          FLOOR COVERING    :      0.00      0.00     201.00       0.00     528.00       0.00    !      729.00     !
:     29          MISC REP & MAINT  :    369.00      0.00      75.00     371.00    2968.00       0.00    !     3783.00     !
:                                   :                                                                    !                 !
:                                   :                                                                    !                 !
:TOTAL FOR BUILDING                 :    915.00   2571.00    9824.00    7521.00   25741.00       0.00    !                 !
:------------------------------------------------------------------------------------------------------------!-----------------!
:------------------------------------------------------------------------------------------------------------!-----------------!
:TOTAL CLASS I, III, IV, V                                                                               !    44001.00     !
-------------------------------------------------------------------------------------------------------------!-----------------
```

Task Screen



```
BLDG  /  410
REF NO   1  DESCRIPTION  INTERIOR PAINTING


***** COST ESTIMATION *****

         DESCRIPTION                         MATERIAL                                LABOR
                              QUAN        UNIT        COST        QUAN         UNIT       COST        TOTAL
------------------------------------------------------------------------------------------------------------

INT  PAINT 2 COATS           20000      0.08 SF    1600.00                                           1600.00

INTERIOR PAINTING                                               140 HRS       28.50     3990.00     3990.00

                                                                                        TOTAL       5590.00
```

Photographs

Where pertinent, photographs are included to further define identified deficiencies.

Conclusions

The next step in the Planned Maintenance Program is the data review by Senior Management who determine how resources are directed. Through the Preventive Maintenance Program, we can detect repairs at a stage when corrections may be made at a lesser cost rather than experiencing a failure and expensive replacement.

Financial Justification

Building valuation and facility renewal. The building value calculated in this section is based on the Marshall Valuation Service. This system provides current average construction cost for various types of buildings. Modifiers are used to account for differences in quality and geographical location. This data base is updated on a regular basis.

The value which has been calculated represents the Current Replacement Value (CRV) of the building. This CRV includes labor, material, architect's fees and contractor's overhead and profit.

The purpose of computing the CRV is to establish a benchmark for reinvestment into the physical plant. The Avenue "A" effort, as outlined in the *Facilities Plan and Funding Forecast 1981-1984*, derived a methodology for computing this annual reinvestment value using a computer driven simulation model. The correlating factor between the forecasted annual reinvestment cost was a percentage value of the CRV. The model yielded a range of one and one-half percent to two and six-tenths percent of the CRV annual reinvestment required over the life of the facility.

Applying this percentage range to Herrin Hall produced the following annual reinvestment figures:

Annual Reinvestment Required for Facility Renewal

CRV of Herrin Hall = $3,918,000
CRV x 1.5 percent = $ 59,000
CRV x 2.6 percent = $ 102,000
MEAN = $ 80,000

The average annual reinvestment for Herrin Hall should fall within this range.

Cost Estimates

This section of the report contains a page for each maintenance requirement identified during the survey. A description of the requirement is given with a detailed estimate of labor, material and total costs.

The first few pages in this section relate to design problems in the Study Project format. These cost estimates normally include only engineering costs.

The cost estimates included are based on "Building Construction Cost Data."[2] The following adjustments to the basic cost data have been made in the estimates.

Labor man-hours have been adjusted for renovation work by ten percent (where applicable). Travel time to and from the job have also been included. These adjustments are reflected in the total man-hours required to perform the work. Computations are to the nearest hour.

Labor costs are based upon Stanford labor rates for 1981-82. No adjustment has been made to account for inflation factors on deferred maintenance projects.

Material costs are indicated in Means, or based upon current catalog prices not included in Means. A fifteen percent overhead and administration charge has been included.

Conclusion for the Stanford Program

The goal of the Planned Maintenance Program was to curb the deterioration of university assets and to restore and maintain each facility in an operational condition. The report was used to justify the need for additional maintenance dollars. The request was justified by the financial analysis and the documentation contained in the reports. Once the additional funding was authorized, the task screen was used as a work order to accomplish the required work. The standard of maintenance has been upgraded and the program is being managed in the academic environment.

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[2] Means, Building Construction Data
Kingston, MA., Robert Snow Means Publishers, 1982.

APPA'84 COLUMBUS, OHIO
CHALLENGES OF PROFESSIONALISM

Wednesday, June 20

Professionalism: The Art of Being Excellent, Exemplary, and Elite

Arliss L. Roaden, President
Tennessee Technological University

Fellow professionals in higher education, I applaud the selection of the conference theme "Challenges of Professionalism," and thank you for inviting me to be a part of this assembly of key university administrators.

Professionalism is the art of being excellent, exemplary, and elite. This definition applies to institutions and people. When I was a child, my father ordered from the Sears, Roebuck catalog most of our clothing and the tools he needed for the farm. At that time Sears classified its merchandise as "good," "better," and "best." Without exception, my father ordered the best even though money was scarce and he had to purchase fewer items and less frequently. He taught that if you can't purchase the best, don't purchase at all--never settle for less than the best. "If you did your best yesterday, you've begun to die; if you are doing your best today, you're beginning to live."

The motto for a fund-raising drive at my university a few years ago was "We are Good." Our appeal was "We are good, but we need your support so we can be the best." That fund-raising drive was more successful than the cumulative efforts of fund-raising drives the previous twenty years. Please note that we didn't say, "If you don't give we will have to close your alma mater;" or "if you don't give we will lose our best faculty members." What we did say to the alumni was, "Your alma mater is a fine university in which you have every right to be proud, and its high quality is deserving of your support."

In my discussions of professionalism, I promise that I will not tell you what professionalism is not; nor will I describe "unprofessionalism." Rather, I shall tell you what professionalism is and the context within which it grows and flourishes.

Excellence

In the exciting, best selling book, In Search of Excellence (Thomas S. Peters and Robert H. Waterman, Jr., Harper & Row, N.Y., 1982), the authors described characteristics of the best-run companies in the country. Their description of the country's excellent, most innovative companies is quite counter to traditional images of tightly run businesses. How many times have you heard that colleges and universities ought to be run like businesses? What these folk have in mind is that colleges and universities ought to be run like the worst-run, not the best-run, businesses--highly centralized, deliberative decision making, conservative policies, a tight ship. Perhaps, In Search of Excellence has taught us that business executives should look to universities and colleges for management models rather than vice versa.

In the excellent companies we are told: "Tools didn't substitute for thinking; intellect didn't overpower wisdom; and analysis didn't impede action." Simplicity is the key. Longfellow wrote that "The supreme excellence is simplicity."

1. The best-run companies have a bias for action--getting on with it. "We need more data" or "the time is not right" more often than not are excuses for indecisiveness. There are some managers for whom you never get adequate information and the timing is never right. An organization with such management is paralyzed in its own straight-jacket. Furthermore, new products are developed and tested by small teams, not hundreds of engineers and other specialists. In our book, *The Research Assistantship: Recommendations for Colleges and Universities* (Phi Delta Kappa, Bloomington, 1975) Dr. Blaine Worthen and I found that productive scholars and researchers rarely come from large R & D centers; rather, they most likely start producing from a relationship with only one senior scholar/researcher. Similarly, excellence in any organization (including physical plant divisions) is manifested by small, relatively autonomous units, with a few top professionals who are models for everyone else.

2. The best-run companies learn from the people they serve. Their best ideas came from listening to customers. Even professionals, *especially* professionals, hob nob with employees and customers in order to learn how to be excellent professionals. They are guided less by MBO (management by objectives) than by MBWA (management by walking around).

3. The best-run companies foster autonomy and entrepreneurship. Imaginative entrepreneurs are turned loose in laboratories and cubby holes--free to produce and make mistakes. Christopher Morley said "Do every day something no one else would be silly enough to do."

4. The best-run companies put their stock in people, rank and file employees, as the source for quality and productivity gain. Every employee is a potential source of a good idea, not just a laborer in the vineyard.

5. The best-run companies are driven by a basic philosophy more so than its equipment, economic resources, organizational structure, or anything else. Several years ago, as a consultant to a school system, I asked the curriculum supervisor about the school's philosophy. She said that she would share the philosophy with me during my next visit. A week later when I returned, she was embarrassed and apologetic. She said that after going through all of the files looking for the school's philosophy, her conclusion was that the school system had "lost its philosophy." "There is small comfort," Boyd Bode said, "in knowing that you are on your way and traveling at a high rate of speed if you don't know where you are going."

6. The best-run companies do only what they know how to do. They avoid becoming a conglomerate of diverse companies.

7. The best-run companies have a simple organizational structure with a lean central staff of top executives.

8. Finally, the best-run companies are centralized around their philosophy and core values; but they are decentralized operationally with autonomy pushed to the shop floor.

Excellence is becoming a watchword for higher education executives--those who operate academic programs and those who operate boiler plants. When you ask your buddy from another campus how things are going, pray that he doesn't describe his slick organizational plan or the growth in the number of employees in his division. If he does, try another buddy, or another, until you find one whose eyes light up as he tells you about something that is happening in his division that, as far as he knows, is the best in the world. It may be growing roses on campus, cleaning the rest rooms, or designing an award-winning instructional laboratory. Daniel H. Burnham was the architect-city planner who designed the city of Chicago and who also wrote:

> Make no little plans; they have no magic to stir men's blood, and probably themselves will never be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency... Let your watchword be 'order' and your beacon, 'beauty.'

My good friend, Professor Jack Frymier of The Ohio State University, just sent me a new book which he and his associates wrote; it is titled, One Hundred Good Schools (Kappa Delta Pi, West Lafayette, Indiana, 1984).

I find it refreshing that scholars are turning their attention to good businesses and good schools rather than the depressing preoccupation with what is wrong and bad about our economic and educational institutions--a preoccupation that has characterized both the professional and popular press during most of my lifetime and yours.

For example, much of the research in psychology has been devoted to deviancies, disorders, and deficiencies; and the presumed key to improvements in everything from factory productivity to performance in government and social service institutions has been to identify the bad practices and stop doing them.

I am thrilled to see these more recent studies on finding the good practices in the best-run businesses and the best schools in America. We are finding out what is right and good and we are saying to problem businesses and schools, "Go emulate these good things and you too will be on the path to excellence."

What characterized the good schools? They are (1) strong administrative leadership that provides for student needs, (2) an emphasis on academic skills for getting the job done, (3) staff development--staff members striving to better themselves in order to do a better job, (4) high expectations for success, (5) a climate of positive relationships and a safe and orderly environment, and (6) adequacy of facilities and resources.

Wherever you find good businesses or good schools, you find a group of professionals who have pride and who have high expectations for success.

Professionalism is fun. It can be like the man who was praying a prayer of thanksgiving for the exhilirating revival meeting he attended. He prayed: "Lord, thank you for the marvelous revival meeting. Lord, the choir was like the voices of angels; the preaching was like the return of the prophets; the spirit was like the flowers in the springtime. Lord, it was so wonderful, I just can't describe it. You should have been there."

Exemplariness

Professionalism is exemplariness--leading by example. Show me an executive who is desk-bound and I will show you an institution that is hide-bound. When Henry Winston became President of Brown University, he reported that he only became effective after he got to the point that he didn't feel compelled to read his mail every day. He learned about MBWA (management by walking around).

The scientific movement in management, which began around the turn of the century, advanced claims that management was alike, the world over, whether you are managing a tomato cannery in Georgia, an automobile plant in Detroit, or a University in California. We now know better than that.

I have two simple rules for employing managers. They must know how to do what they are managing; and they must believe in the institution and the service they are managing. Every time I have violated either of those rules, I've been burned. Beware of the managerial candidate who "has skills; will travel." All of us are familiar with the chronic job seeker. He has a few thousand resumes printed up and mails them to every institution that has a job vacancy listed in the Chronicle of Higher Education. I received one recently which was addressed to me on the envelope, with the letter heading addressed to another president and the salutation of the letter directed to a third president. And he had the nerve to call me for an appointment! If a resume shows a pattern of moving on every three or four years, I can guarantee a legacy of failures left behind. If you hire such a person, no matter how smart or well educated he is, you will be the next victim of a "hit and run" artist who leaves employees and operations in disarray.

Excellent managers have a common calling card; they are committed. They believe in what they are doing, and they believe in the institution where they are doing it. Edgar Dale, Emeritus Professor at The Ohio State University wrote, "In a democracy no man has the right to be ignorant about the basic institutions under which he lives. He may have other rights but he does not have this one." I would add that no professional has the right to speak disparagingly of his institution. If he doesn't believe in it, he can't lead it. Sam Rayburn said, "Any jackass can kick a barn down, but it takes a good carpenter to build one."

A part of being exemplary is setting the tone for excellence--doing the best and being the best. Some boxing fans were offended by Muhammad Ali's claim, "I am the greatest." I wasn't offended. He was the greatest. Excellence is no cause for humility. We are taught that "The meek shall inherit the earth." A recent cartoon had one arch angel reporting to another that "the meek were contesting the will."

One of my favorite stories is of Arthur E. Little. He was offended by the old saying, "You can't make a silk purse out of a sow's ear." It seemed to him that too many people accepted the defeatist attitude that there are certain things you cannot do and a classic example was "You can't make a silk purse out of a sow's ear." Little proceeded to spend thousands of dollars on proving that it could be done. A Chicago meat packing firm provided one hundred pounds of ears which were reduced to a glue and then, through various chemical operations, turned into a kind of silk. This was hand woven into a purse. That silk purse from a sow's ear is today on exhibit in the Smithsonian Institute, along with Lindberg's airplane and John Glenn's space capsule. Arthur Little never viewed his achievement as being anything extraordinary in chemistry, but he did view it as an extraordinary accomplishment in philosophy, to change the attitudes of people who claimed that certain things could not be done.

I like, also, the philosophy of the elderly farmer who when asked if he had lived all his life on the same farm responded, "not yit."

Elitism

In Doctor Zhivago, Boris Pasternak wrote, "The fabulous is never anything but the commonplace touched by the hand of genius."

Elitism, once considered a virtue in our society, regrettably, has fallen in disrepute. Elitism has been viewed as being contradictory to the democratic principle of egalitarianism. In the late 1960's and early 1970's, we went through a great leveling period, and we succeeded. Almost everybody became mediocre. Test scores plummeted, aspirations for success declined, and the number of merit scholars dropped alarmingly. Only recently have the measures of academic aptitude begun a very slow recovery. We were misguided. We confused equality of opportunity for equality of achievement. I believe in equality of opportunity with all of my strength of conviction. I do not believe in equality of achievement or performance. When I speak to students, I tell them to be elite and proud of it. Elitism, however, is not restricted to academics.

Professionals are elite. They should be rewarded accordingly. Professional physical plant administrators are elite. Professional custodians are elite. Professional garbage collectors are elite.

On our campus, there used to be the practice of assigning the oldest, most unsightly vehicles to the maintenance staff. We stopped that practice. What kind of pride can you build in a maintenance staff who drive around campus in hand-me-down, rattle-trap cars? When we purchase new vehicles for the motor pool, we purchase new service trucks and vans for the maintenance department. I want the garbage truck from my campus to be the slickest truck at the dump.

The custodial and maintanance jobs on campus are too important to be relegated to non-professionals.

Economist Eli Grinsberg told of his visit with Prime Minister David BenGurion during the rebuilding of Israel. He questioned the Prime Minister about the wisdom of starting a program in higher education at a time when the

Israel economy required truck drivers, hod carriers, masons, and carpenters. BenGurion was furious that questions were being raised about his priorities on education. "Whoever said that those who carry out the rebuilding tasks of our nation should be ignorant?," he asked. "Those truck drivers, hod carriers, masons, and carpenters who carry out the laborious tasks of rebuilding the nation deserve to be educated similarly to those who oversee the rebuilding," he said.

So, I ask you, "Whoever said that everyone on college and university campuses should be educated, have the finest tools, equipment and facilities except for the custodial and maintenance workers?" We should be as proud of centers of excellence in the physical plant division as we are of centers of excellence in the chemistry department. I am. And I want to say "thank you" for making it possible for teaching and learning to take place on campus in an environment of excellence and beauty.

When I corrected my children as they were growing up, their response often was, "Nobody is perfect." I have never quite believed that phrase. Perhaps they were correct in the particular but incorrect in the generalization. There is no greater imperfection in our society than a populace that has less than perfect aspirations and goals. Yes, "A man's reach must exceed his grasp, else what's a heaven for?" "Ideals are like stars. You will not succeed in touching them with your hands, but like seafaring men on the desert of waters, you choose them as your guides; and following them you reach your destiny."

Charles F. Kettering, the genius engineer from Ohio, once wrote, "Nothing ever built arose to touch the skies unless some man dreamed that it should, some man believed that it could, and some man willed that it must."

Professionalism is the art of being excellent, exemplary and elite. Who wants to be a professional? I do. You do. And every man and woman on your staff wants to be a professional. The recipe is simple: "Make no little plans; they have no magic to stir men's blood. Make big plans. Aim high in hope and work. Let your watchword be order and your beacon beauty."

No doubt you are ready to join me in another little verse:

I love a finished speaker
I really do.
I don't mean one who's polished
I mean one who is through!

THE IMPACT OF INSTALLING A NEW TELECOMMUNICATIONS' SYSTEM ON PHYSICAL PLANT ADMINISTRATORS

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Introduction

This paper will discuss, and attempt to explain, the impact of the divestiture of AT&T and the resulting changes in telecommunication systems on Physical Plant Administrators. The information contained herein is based on a single encounter with this very complicated topic - the events and investigations that produced the request for proposals (RFP) that were recently received for a new telecommunications system at the University of Georgia (UGA). The results and conclusions presented here may not, however, be universally applicable, since there are peculiarities in the way UGA purchases telecommunications services, and since the main campus at UGA is served by an outdated and nondedicated system located off campus. However, the involvement on the part of UGA in investigating modern telecommunication systems has been sufficiently intense to suggest several important conclusions which may be useful to other member institutions.

This paper will not discuss, nor attempt to explain, the history of the divesture, the timing of divesture events, or recent court decisions involving AT&T and the resulting companies that have emerged. For the purpose of this paper, it will be assumed that costs for all forms of telecommunication service have already changed, or will change, significantly in the near future, and that the means of delivering these services will no longer be handled in traditional fashion. These facts, coupled with the advances in technology which make many desirable electronic telecommunication features available now, have caused many large consumers to evaluate their existing systems. Based on such an evaluation, UGA concluded that changes were indicated, and an RFP was issued; it would be assumed that other institutions will make, or have already made, similar requests.

Existing Conditions

The main UGA Campus is served by a large central office telephone exchange located several blocks from the campus; this facility is not dedicated exclusively to the University, and handles many additional private off-campus lines. Exterior cabling on the campus is a mixture of aerial and underground circuits. Interior cabling runs the gamut from carefully planned to chaotic; much of this cable is old, and it is difficult to evaluate individual building systems since few record drawings exist for telecommunication wiring. Several building branch exchanges are located in campus buildings, but, in general, all intracampus calls are run off-campus through the central office, and then back to the campus. Several hundred dedicated voice-grade telephone lines have employed for data transmission; a majority of these lines terminate in the UGA Computer Center located on the South Campus.

Another factor which may make the UGA experience atypical is the presence of an intermediate state agency, the Department of Administrative Services (DOAS). Conceived in the gubernatorial administration of Jimmy Carter, this agency acts as a master purchasing agent for various other state agencies, and in this capacity contracts with providers of telecommunication services for the State. Thus, UGA, as a member of the University System of Georgia, is a customer of DOAS, and does not deal directly with "the Telephone Company" for these telecommunication services.

UGA Physical Plant involvement in the existing telephone system has been minimal at best. Aside from assigning small spaces for switching equipment and terminal boards, or installing an occasional conduit to accommodate dedicated computer lines, the telephone system at UGA has been given little attention, since the responsibility for installation and maintenance is not Physical Plant's.

In other respects, however, UGA displays the typical needs of an institution for data transmission, video transmission, and voice transmission enhancements and features. Installation and maintenance of the existing system has been handled traditionally by "the Telephone Company". In addition, there are pressures both for and against any proposed system change; this ambivalence is to be expected in a community of the size and diversity of UGA. Based on these observations, it is not unreasonable to conclude that the UGA exposure to the telecommunication dilemma may suggest information which will be helpful to other institutions.

The Request for Proposals

The administration at UGA established a telecommunication committee to investigate the communication needs of the campus, and to suggest appropriate alternate systems if the installation of a new system was indicated. The committee met with DOAS representatives, suggested that data communication requirements could not be met with the existing system, and also pointed out that voice enhrancements were not available campus-wide for existing telephone sets. It was decided to conduct a survey to determine the existing and future needs of the campus, based on a sampling of the needs of all University departments.(1) The results of this survey were used to help develop the RFP, which was authored by DOAS; approximately 8000 sets are required at initial cut-over.

In the Fall of 1983, DOAS issued the RFP to all prospective offerors. Proposals were originally scheduled to be received in November of 1983, but it was decided to change this date until after January 1, 1984, so that a certain company could legally offer a proposal. In January, nine RFP's were received by DOAS; these were all quite involved and lengthly (with the exception of the RFP from the company that was legally unable to engage in this activity until January 1, 1984) and included not only technical but financial data(2). To evaluate both the technical and financial data presented by each offeror, DOAS prepared a three part evaluation guideline. The first two sections covered technical data, and will be discussed at greater length hereinafter. The best technical proposal was to receive 100 points, with other offerors receiving proportionately lower scores. The third evaluation section covered financial data for each RFP; DOAS elected to withhold the financial data from the UGA Telecommunication Committee until all technical data were evaluated. The total financial proposal for each offer was expressed in terms of lowest seven-year cost for the features offered by each company(3). The Offeror's proposal for the lowest cost was assigned 100 points, and other offers received a proportionally lower score. Since the financial data is still considered to be proprietary information by the Offerors, no actual cost data will be presented in this paper. However, it should be noted that the highest dollar bid was double the lowest dollar bid. Results of the RFP process should be made public in the near future, after a contract is signed.

The final score for each offer was the sum of the technical score (100 maximum) and the financial score (100 maximum). Thus, DOAS elected to weigh the technical and financial data equally.

Technical Data Guidelines

As indicated, two sections of the evaluation guideline covered technical data (these are contained in Appendix I). Section One addressed the "PBX" requirements of each proposal; this Section essentially covered the voice handling capabilities of the system, under the general headings of Reliability, Efficient Operation, Manageability, Flexibility, and Compatibility. There were 30 scoring categories, with a maximum possible score of 362 points. (Note that an issue of great concern to Physical Plant, a category involving the "amount of disruption to the Purchasers's Property due to cabling and wiring," allocated a maximum of 20 points to the "best plan," but provided no automatic rejection of an RFP with an unacceptable plan.)

The second section of technical evaluation data covered 16 "optional" feature categories. However, DOAS required that one of these features had to be included in the RFP: all offerors were required to present information on integrated voice/data communications. The other 15 categories were truly optional, and covered high speed data transmission, local area network support, call detail reporting, modem pooling, hotel/motel features, directory/inventory features protocol conversion and other essentially software-driven features. The total maximum score available in this optional section was 198 points, with a maximum score of 45 possible for the mandatory integrated voice/data feature.

Evaluating the RFP

Upon receipt of the RFP's, DOAS spent several weeks in preliminary review. UGA personnel then reviewed each of the nine offers, and suggested that each Offeror make a presentation to both UGA and DOAS to explain in detail certain key points, mainly concerning switch capability, data transmission, and methods of cabling. These meetings took place in late March and early April of 1984.

Several factors were brought into focus during review and presentations by each Offeror. First, the digital switch seems to be firmly entrenced as the switch of the future, and digital transmission of voice, data, and video signals is at hand. Secondly, the technical evaluation for Section One, the "PBX" requirements, became difficult because all nine offers appeared to be more or less capable of handling these needs. (As an aid to this evaluation, UGA Physical Plant used a computer-based multicriteria decision-aid model called "Electre"; information concerning this model is contained in Appendix II.) Third, all offerors were more or less guilty of selling from next year's catalog; reviewers heard much more about software and features "scheduled in second quarter 1985" than features "up and running now." Finally, some Offerors had to be prodded more than just slightly to admit certain facts(4). Evidently, both the size of the project and the "RFP syndrome" produced a particularly strong sense of reluctance to reveal information. (For further discussion on the RFP syndrome, and RFP's in general, see Appendix III.)

Subsequently, DOAS has requested "best and final" offers from the companies, based on a slightly refined request. These revised RFP's were received on June 7, 1984, and are being reviewed at the time this paper is being presented.

Implications for Physical Plant Administrators

Based on the UGA experience with an RFP for a new telecommunication system, it seems that Physical Plant Administrators should consider the following factors if their institution plans a similar move.

1. If exterior cabling is required, it should be installed underground wherever possible.(5) Physical Plant personnel should determine where cable runs will be located. In an urban setting, plant designers should work closely with municipal authorities in placing outdoor cable. No one, especially a vendor attempting to become the successful low bidder, knows the subsurface conditions on a campus or under a local street better than plant personnel. A detailed plan of this cabling should be made part of the contract.

2. If communication equipment rooms are required, they should be selected in each building, and made part of the contract(6). Spaces should be allocated only after agreement is reached with the building occupants and Physical Plant. Remember that a modern telecommunication system requires environmental control and standby power supply for major equipment locations.

3. If interior cabling is required, Physical Plant personnel should help determine where cable runs will be located, and how individual station locations should be wired(7). Areas where teflon-coated (plenum rated) cable is required should be indicated in all affected buildings.

4. If any building areas involved in the project contain asbestos materials, these materials must be removed first before interior cabling can be installed(8). Remember also that previously encapsulated asbestos materials may also require removal if these materials are subject to damage during cable installation.

5. If data transmission capabilities are included, additional 120 volt power may be required at station locations for local modems, CRT's or other peripherals. Since there is a code limit to the number of receptacles allowed on a 20-ampere circuit, additional panels may be required if spare circuits are not available. Also, low voltage power may also be required locally if the installed system does not provide transformed power at each station location.

6. If outside contractors install cabling or equipment, make sure that licensed electrical contractors are specified to install all work which is covered by the National Electric Code. Also, require the installer to carry Contractor's Liability Insurance, and to follow all the requirements of a typical construction contract.

7. If new cabling is required to be installed, whether interior or exterior, specify that a complete set of as-built drawings must be given to Physical Plant before final payment is issued.

8. If equipment installed on campus is to remain the property of the Offeror, spell out in the Contract the extent of his liability for that equipment, especially as it affects the building and its contents.

9. If equipment is installed on campus, arrange to have all services and utilities metered, so that these costs can be allocated and recovered properly.

10. If a new system is installed, remember that Physical Plant will also be a consumer of these new services. Some institutions may elect to use a new system for monitoring, control or operational functions which are presently not available, or handled by separate systems(9).

11. Finally, if a new telecommunications system is designed or installed, someone has to pay for the considerable time and effort required on the part of Physical Plant personnel(10). A new system will affect every floor of every building on campus, and there is no way to avoid involving plant personnel in a project of this scope.

Conclusion

The world is entering the age of the digital switch, and integrated telecommunications systems capable of handling voice, data, text, and image are now being marketed. This technological breakthrough has occurred partly because of, and partly in spite of, the divesture of AT&T. Every member institution of APPA is affected by this simultaneous change in technology and change in the traditional method of providing telecommunication services. Physical Plant administrators should plan as carefully and thoroughly as possible for this new era, since they will surely play a large part in these changes.

Footnotes

(1) Surveys for new telecommunications systems should be based on sound traffic engineering principles, in addition to conventional sampling methodology. The American Management Association publication "Telecommunications Management - A Practical Approach" contains an excellent chapter on traffic engineering, in addition to an excellent Glossary covering "Telephone Company" terms. (New York City: American Management Association Membership Publications Division, 1984).

(2) [illegible] nine RFP's were received from the following companies(Switches in parentheses):

A. Southern Bell (SL-100 on campus)
B. Southern Bell (DMS-100 off campus)
C. General Telephone & Electronics (GTD 4600)
E. Universal Communication Services (NEAX 2400)
F. Intecom (IBX S/80)
G. Continental Telephone (SL-100)
H. AT&T (Dimension 85)
I. AT&T (Dimension 85 + WPN)
J. Rolm (CBX-9000)

(3) Cost data for a broadband coaxial system, to be installed as a separate entity, was also made available to DOAS by UGA. UGA had investigated costs involved in providing data and video access via this broadband network to 20 percent of the existing telephone set locations on campus. These costs, when combined with the cost of operating the existing telephone system, provided an alternate solution to the problem of providing adequate voice and data capabilities for the campus community.

(4) One of the Offerors would not indicate the proposed location of outdoor cabling, claiming that this was design information and that his firm was not prepared to provide "free" design before signing a contract. UGA personnel considered this position to be ridiculous , since we were infinitely more concerned about our grounds and buried utilities than his company's cable design.

(5) DOAS did not insist that all new exterior cable had to be installed underground, and did not specify means of installation if cable was located below grade. UGA feels that all exterior cable should be installed underground, in conduit, in a concrete envelope.

(6) DOAS did not designate equipment room locations in the RFP, since they felt that in so doing they would favor one system over another. Offerors indicated in their proposals room sizes and locations that they felt they needed for their systems. It may prove to be very difficult for UGA to provide these spaces exactly as the Offeror requested.

(7) DOAS did not designate cable run locations in each building, nor did they specify whether individual stations should have exposed or concealed wiring. DOAS did specify that all interior cabling had to be installed in accordance with the National Electric Code and all other applicable building codes.

(8) At the time that the RFP was written, the State of Georgia was completing an asbestos survey of all educational facilities. A report has recently been made available to UGA indicating that several buildings on campus contain asbestos materials.

(9) UGA Physical Plant does not plan to use the proposed system for energy management purposes, since a dedicated system is already installed on fifteen campus buildings. However, we do covet many of the features of a new system, and hope to be able to take advantage of them.

(10) UGA Plant personnel were not funded specifically for involvement in the RFP process, and as a result spent only a limited amount of time on the project.

APPENDIX I

SECTION ONE
PBX EVALUATION

Weight **Reliability**

1 Conformity of the Offeror's Response to the RFP.
- 3 - Meets
- 1 - Has restraint
- X - Does not meet

4 The Quality of factory support received by the offeror from the switch equipment manufacturer.
- 3 - Letter enclosed with no restraints
- 1 - Letter enclosed with restraints
- X - No letter

3 Past Proven Product Performance

Procedure - calls will be made to customers asking would you buy this same product from the same vendor again?

The same number of calls will be made for each proposal
- 5 - 100% would buy same product from same vendor again
- 4 - 80% would buy same product from same vendor again
- 3 - 60% would buy same product from same vendor again
- 2 - 40% would buy same product from same vendor again
- 1 - 20% would buy same product from same vendor again

2 Proposed System's Diagnostic Capabilities.

Alarm Panels
- 5 - Vendor RMATS center conducts monthly diagnostics; proposed system clearly has visible, on premise, major and minor truck alarms; OPX's and trunks operation checked automatically by system
- 4 - Same as above but no monthly diagnostics conducted
- 3 - Major and minor alarms highly visible on console
- 2 - No alarms on console
- 1 - Major and minor in equipment room only
- 0 - No alarms, no system self diagnostics possible

3 Past Proven Vendor Performance

Procedure - The length of time the vendor has been in business will be determined; i.e., when it was incorporated and licensed to do business in the State of Georgia
- 4 - 5 Years or more
- 3 - 1 through 5 years
- 2 - Less than one year

3 Vendor Responsiveness in the areas of moves and changes of equipment

Number of days required for new installations and moves
- 5 - Best interval provided less than 5 working days
- 4 - Next best interval less than 5
- 3 - 5 days
- 2 - 6 through 10 days
- 1 - Over 10

Weight	Reliability
4	Offeror's Service Center Location 5 - Located within 25 miles of switch installation 3 - Located within 50 miles of switch installation 1 - Located within 75 miles of switch installation 0 - Located greater than 75 miles of switch installation
3	Offeror's Proposed Repair Response Time 4 - Better Response proposed than 4 hours (major), 8 hours (minor 3 - 4 hours (major, 8 hours (minor) 2 - Poorer response than 4 hours (major), 8 hours (minor)
2	Maintenance Billing Procedures offered by the Vendor. 3 - (1) No mileage charges (2) Billing time begins on repair site 2 - Mileage charges or charges portal to portal
1	Equipment MTBF 3 - Best 2 - Next best 1 - All others 0 - No information provided
1	Equipment MTTR 3 - Best 2 - Next best 1 - All others 0 - No information provided
3	Equipment Warranty Provisions 5 - Proposal with the most years, equipment and labor, provided by warranty 3 - Proposal offering warranty that provides 1 year equipment and labor 2 - Proposal offering warranty that provides 1 year w/o labor 1 - Proposal offering warranty that provides less than 1 year w/o labor 0 - No warranty offered
4	The Amount of Redundancy offered by the Proposed System 5 - Most redundant system 4 - All others 3 - Least redundant
	Efficient Operation
3	Internal Switchgear Capacity 5 - Non blocking 4 - Meets P.01 24 BHCCS/Station 3 - Meets P.01 18 BHCCS/Station 0 - Less than P.01 18 BHCCS/Station

Weight **Efficient Operation**

1 Design and Method of Operation of the Console

Procedure - Evaluator will check for alpha numeric display, BLF, identified operating buttons, adj. audio-visual controls

5 - All 4 items included in offerors proposal
4 - 3 items included in offerors proposal
3 - 2 items included in offerors proposal
2 - 1 item included in offerors proposal
0 - No items included in offerors proposal

2 Ease of Operating the System Features from an individual single line, 2500 type, station set

5 - One touch access for all features
4 - Two touch for all features
3 - 50% 100% of all features with 2 touch
2 - 50% with 3 touch
1 - 4 touch access on more than one feature
0 - No information provided or available

3 Environmental Requirements of the System proposed

5 - No equipment room required
3 - Least size equipment room
2 - All others requiring 25 percent greater floor space
0 - No information provided

3 Uninterrupted Power Supply

5 - No interruption of service or memory for 24 hours
3 - No interruption of service for 24 hours (some reprogramming required)
2 - No interruption of service or memory for 12 hours
1 - No interruption of service or memory for 8 hours
0 - No interruption of service or memory for less than 8 hours

2 Commerical Power

4 - Vendor provided
3 - Purchaser provided

4 Amount of Disruption to the Purchaser's Property due to cabling and wiring

Procedure: Each Proposals cabling plan will be evaluated with special emphasis to the following:

1) Amount of aerial cable runs.
2) Amount and procedure of trenching.
3) Amount of customer provided conduit required.
4) Amount of customer provided special equipment, i.e. weatherheads, pot heads, etc.
5) Type and location marking and access on cable splices.
6) Amount of proposed involvement on the part of the purchaser.

5 - Best plan
4 - Better plan
3 - Good plan
2 - Fair plan
1 - Poor plan
0 - Unacceptable plan

Weight   Efficient Operation

4   Efficiency of the Proposed System's Handling of Switched,Dial-up, Modem Driven, Data Communication.
5 - Meets 4800 & 9600 band requirement and fully bit transparent
4 - Meets 4800 and fully bit transparent
3 - Meets 4800 and has limitations on bit transparency
2 - Has severe limitations on 4800 or bit transparency but not both
1 - Has severe limitation on 4800 and bit transparency
0 - Does not meet 4800 requirement and bit transparency

Manageability

4   Degree of Modular design of the system.
Modular cabinets, modular circuity, future software upgrades at minimal expense
5 - All of the above
4 - 1 & 2 of above
3 - Modular circuit packs
2 - None of the above

1   Quality of the Documentation Supplied
3 - Has all components
2 - Leaves one out
1 - Leaves two out
0 - Leaves three or more

3   Training supplied by the Offeror
4 - All station users and attendant trained initially with no out of town travel
3 - Station users and attendant trained initially
2 - Counselor training of all three
1 - Counselor training of less than all three

3   Offeror's Response to the other non-Technical Requirements that would result in greater overall manageability of the installation and operation of the proposed system.
5 - Exceeds best
4 - Exceeds at least one requirement
3 - Meets requirements
2 - Does not meet all
1 - Meets least
X - Fails to completely respond to any one of the above paragraphs

Flexibility

2   Other Stated Service Intervals (besides new installations and moves of equipment)
5 - Exceeds all intervals
3 - Meets all intervals
1 - Does not meet all intervals
0 - No information provided

Weight   Flexibility

2   Other Operational Service Features
4 - Offer unique advantage

Compatibility

4   CCSA Network
4 - Acceptable CCSA compatability + system offers an enhanced network feature
3 - Acceptable CCSA compatibility
2 - Requires two digit dialing to access network
X - No CCSA compatibility

4   AIOD Capability
3 - System offers AIOD or acceptable (at sole discretion of purchaser) alternative
X - System does not have AIOD or acceptable (at sole discretion of purchaser) alternative

4   Operating Telephone Companies
3 - Proposal states proposed system meets FCC PART 68 & PART 15
1 - Proposal states proposed system only meets PART 68
X - Proposed system does not meet FCC PART 68

SECTION TWO
REQUESTED
OPTIONAL FEATURES

Weight

1 Auxiliary Equipment

5 - Offers all suggested items of equipment and other beneficial devices
3 - Offers the suggested items only
2 - Offers at least 75% of suggested items
1 - Offers at least 50% of suggested items
0 - Offers less than 50% of suggested items

2 Directory/Inventory Software

5 - Offers capability and memory to handle cable inventory for 10,000 lines and directory lookup for 12,000 lines (4,000 students, 7,500 administrative, and 500 growth)
3 - Offers capability and memory to handle cable inventory and directory lookup for 10,000 lines - i.e. administrative system (with growth) needs only.
1 - Offers capability and memory to handle directory lookup and cable inventory for at least 8,000 lines (i.e. administrative needs with no growth after first year) but less than 10,000 lines.

9 Integrated Voice/Data Communications

5 - Utilizes digital instrument, no "modem eliminator" type adjunct, one pair distribution, smaller amount of degradation in bhccs capacity as compared to the other proposals, and earliest capability of 9.6 kbps asynchronous transmission speed.
4 - Utilizes digital instrument, no "modem eliminator" type adjunct, two pair distribution, no more than 25% bhccs degradation, and 9.6 kbps asynchronous transmission speed by 2nd quarter 1985.
3 - Same as above but has greater than 25% but less than 50% bhccs degradation and utilizes 3 pair distribution.
2 - Utilizes modem eliminator, requires greater than three pair distribution, 9.6 kbps asynchronous rates offered no sooner than 4th quarter 1985, and no more than 50% bhccs degradation.
1 - Offers simultaneous Voice/Data but with other operational limitations in addition to those listed in #2 above.

High Speed Data Transmission.

Weight

2 Asynchronous

- 5 - Earliest availability (prior to 1st quarter 1986 and others within 3 months of this date) of asynchronous 19.2 kbps with reasonable equipment software changes.
- 4 - Next earliest availability (prior to 1st quarter 1986 but greater than 3 months from #1 above) of asynchronous 19.2 kbps with reasonable equipment/software changes.
- 3 - All other proposals offering asynchronous 19.2 kpbs by 1st quarter 1986 with reasonable equipment/software changes.
- 2 - All other proposals offering asynchronous 19.2 kbps by 1st quarter 1987 with reasonable equipment/software changes.

2 Synchronous

- 5 - Earliest availability (prior to 1st quarter 1986 and others within 3 months of this date) of synchronous 56 pbps with reasonable equipment software changes.
- 4 - Next earliest availability (prior to 1st quarter 1986 but greater than 3 months from #1 above) of synchronous 56 kbps with reasonable equipment/software changes.
- 3 - All other proposals offering synchronous 56 kbps by 1st quarter 1986 with reasonable equipment/software changes.
- 2 - All other proposals offering synchronous 56 kpbs by 1st quarter 1987 with reasonable equipment/software changes.

2 Interface Requirements

- 5 - Meets all listed interface standards

1 Digital Transmission Support

- 5 - Acceptable interface provided

2 Modem Pooling

- 5 - Acceptable modem pooling provided

Weight

1 Authorization/Account Codes

- 5 - Acceptable feature provided

1 Call Detail Reporting

- 5 - Acceptable feature provided

2 Protocol Conversion

- 5 - Offers fastest, customer location tested, format and protocol conversion allowing the highest # of dissimilar devices to communicate
- 4 - Meets above but not customer location tested but lab tested.
- 3 - Provides acceptable feature but does not meet qualifications on speed or customer location testing, of 4 and 5 above

3 Coaxial Connection to the Integrated Voice/Data Station Line

- 5 - Offers this feature with no terminal contention for transmission link
- 3 - Offers this feature with contention of no greater than 32 terminals per path

3 Local Area Network (LAN) Support

- 5 - Offers fastest, customer tested location, acceptable feature
- 4 - Offers either the fastest or a customer location tested, acceptable feature
- 3 - Offers acceptable feature, has been lab tested and can be demonstrated

2 Dedicated Circuit Software Support

- 5 - Offers acceptable feature

1 Data Class of Service

- 5 - Offer acceptable feature with largest number (over 250) of available data classes of service without degradation to voice features
- 3 - Offers a minimum of 250 available data classes of service without degradation to voice features.

2 T1 Compatibility

- 5 - Offers acceptable features

ADDITIONAL OPTIONAL FEATURES
= up to 18 pts.

APPENDIX II

A COMPUTER BASED MULTICRITERIA DECISION-AID MODEL

As an aid to evaluating the technical data of each proposal for the "PBX" requirements, UGA Physical Plant engineers turned to a French-developed model for decision making known as Electre. This model is featured in a book by X.T.Bui entitled "Executive Planning with Basic" (Berkeley, CA, Sybex Co., 1982). This work contains explanations and listings of computer programs, written in BASIC language, for various management and decision making models.

The Electre model was selected because it allows analysis of several criteria simultaneously, and also allows for subjective evaluation of these criteria. This model is based on paired comparisons of the various criteria among competing sources. The program compares each decision criteria among all proposals, and will select a "best" proposal provided this proposal is better than all others in a majority of criteria and is clearly not worse than any other in a single criterion. The concordance (a majority favor) and discordance (no criterion favors another excessively) coefficients can be sensitized to add subjectivity to the process - i.e. the program can be manipulated to favor concordance or discordance, and thus put more or less emphasis on these factors. In addition, criteria can be weighted to place different levels of importance on each criteria.

UGA engineers revised the listing in the printed model to reflect a slightly different dialect of BASIC (the UGA program is written in Microsoft BASIC), and to allow the program to run with an array large enough to accommodate the relatively large number of criteria (30) on a TRS-80 Model II machine. The program did not select a clear-cut "winner" in this case, since several proposals were fairly evenly matched. It did, however, add a sense of credibility to the evaluation process by comparing the different criteria dispassionately. After reading the first few proposals, or listening to several presentations,all the information tends to run together; this program seemed to keep all pertinent data properly sorted. UGA engineers have also used "Electre" in helping evaluate Architectural/Engineering firms for selection to design a new Biological Sciences Building on campus, and are planning to use this model to help prioritize remodeling and renovation projects.

The remainder of the Bui book contains other useful programs such as decision models under certainty (Simplex linear programming) and models under uncertainty (CPM and PERT). Another excellent reference for decision models is "A Primer for Policy Analysis" by Edith Stokey and Richard Zeckhauser (New York: Norton Co. 1978); this book does not contain program listings, but gives a thorough background on decision models in general, and also discusses the specific decision-making methods most widely used today.

APPENDIX III

RFP's and the RFP Syndrome

Many institutions use the Request For Proposal method to procure services or systems. In theory, the RFP allows the requestor to take advantage of the special expertise of the Offeror, and allows the Offeror to present his best solution to the problem. Thus, an RFP is predicated on a lack of complete knowledge on the part of the requestor, or his inability or unwillingness to learn a universe of information about a subject, due principally to time constraints. This often produces an "RFP Syndrome", where the Offeror assumes conceptual ownership of the project (after all, he is designing it) to the exclusion of all other parties including, unfortunately, the Owner. It is important that the Owner insist on having enough information presented to him to make a rational decision while protecting certain proprietary or confidential information of the Offeror.

RFP's have historically been used in Research and Development projects, where goals are generally known but where means to these goals cannot be specified. RFP's have also been used extensively in the procurement of computer systems and similar high technology equipment, where components are physically available, but not in the proper combination at the time of the request. There are pitfalls, however, to be avoided when using an RFP for procuring services or systems. If the requestor is fairly certain of both the means and the ends desired for either the entire system, or logically separable components of the system, these elements should either be deleted from the RFP and handled separately on a "furnish and install" contract, or they should be specified in precise detail in the RFP. In addition, requestors should carefully consider all predictable outcomes that will result from implementation of the RFP, and also be prepared to face unforeseen consequences which, more often than not, seem to accompany such implementation.

Management and public policy literature contains many case studies about the complexity and nature of the RFP process. The reader's attention is called to the RFP and subsequent events surrounding the Department of Defense experience with the procurement of the C5-A aircraft; the book "Designing Public Policy" by Laurence E. Lynn, Jr. (Santa Monica, CA. Goodyear Publishing Company, 1980) denotes two chapters to this contract.

AN ADMINISTRATOR'S GUIDE TO CHANGING TELEPHONE SYSTEMS

By Phyllis Rossiter Forbes
University of New Hampshire

When I acquired the responsibility for the Telecommunications Office at the University of New Hampshire in 1980, I viewed it with a kind of bemused detachment. After all, telephones are rather unexciting devices that, depending on your point of view, either provide a pleasant link with the world or an unpleasant infringement upon one's privacy. At that time, Telecommunications was lumped in with the unit that provided maintenance dispatching, work scheduling and did the payroll and billing for the physical plant division. Needless to say, it did not get too much attention in its own right.

It first grabbed my attention when, in one month's time, the bill for equipment rental at the University went up $10,000, or twenty-five percent. Had we had "state-of-the-art" equipment, I might have been a little more sanguine. That was not the case, however. UNH, like many universities, is served by a Centrex II, controlled by a #5 Crossbar Central Office. For those of you not initiated into the jargon of telecommunications, a #5 Crossbar Centrex is an "antique" - an electro-mechanical system totally outdated in the computer age. In addition, the cable plant was so old that rainy days created chaos in certain areas of the campus when pits flooded and consequently, communication along that stretch of cable plant became problematical.

Like most things, one can learn to live with obsolete equipment if one does not have to pay an arm and a leg for it. Unfortunately, that was not the case. Judge Green's divestiture agreement was being put together and the members of Ma Bell's management team were scratching their heads and trying to figure out how to function successfully in a competitive environment. One of the results of their collective wisdom was something called the "installed-based migration strategy." This stroke of genius dictated that the way to "sell" customers on newer equipment was to increase the prices on the older installed equipment (namely, Centrex) to the point that replacement with "newer" Bell equipment would be less expensive. (To give you an example: In September 1980, UNH paid $35,000/month for equipment rental; today, it is $60,000/month for the same number of phones.) At that time, the newer Bell equipment could not be purchased, however. Instead, Bell conceived of the "Variable Term Payment Plan" (VTPP), whose prices looked very good until renewal - and then they took huge jumps, much as they do for the Centrex equipment. Bell had two aims: first, they were scrambling like mad to corner as much of the market as possible before divestiture, thus locking customers into 4,6 and 8 year contracts; and they were selling already outdated analog equipment. Not a bad strategy when one considers that, for years, colleges and universities have turned the "management" of their telephone systems over to Bell and have often not required competitive bidding on new systems because the phones fell into the category of "an upgrade to current equipment".

UNH has just spent two years in the process of going out to bid for a new telephone system. We have spent a lot of time and money (both profitably and unprofitably) and I'd like to share some insights (or perhaps they are better called "hindsights") with you. The following are a list of guidelines (which are reproduced on the handout) for those of you who are, as I was, totally unschooled in telecommunications.

1. Hire a Consultant

   If you have a qualified telecommunications manager, so much the better. If you do not, a consultant is an absolute necessity. Consultants who are active in the field tend to keep up with state-of-the-art improvements. In addition, most of them have been through the process before and have turned it into a fine art. They can help you avoid some costly and embarrassing mistakes, even if you have a manager. A warning is in order here, however. Be sure the consultants are qualified to handle your account. If you have a large or complex system, don't hire someone who has no proven experience in the area. Contingency (percent of savings) contracts are to be avoided at all costs. Anyone can save you money; but you may end up without dial tone.

2. If you don't have a qualified telecommunications manager, hire one.

   If your telephone system is large enough to justify a full-time position, you are wasting money by not having someone dedicated to the task. Look at what you are paying each month for telephone service. If you are like UNH, then you are spending between $50,000 and $60,000 per month for three thousand lines. If you are not able to justify a full-time position, consider educating one of your computer geniuses (there are all sorts of courses available) and assigning him/her to the task. What you are likely to find is that the job will grow into a full-time one very quickly. Only minimal gains will justify the salary. At $60,000 per month, a 5 percent savings is $36,000 per year.

   Another option is to place telecommunications under your computer center. Be wary, however; voice and data communications are quite different and voice should not take second place to data. Case in point: Computers go down quite regularly and no one thinks much of it. You cannot have that happen to your phones or you'll be out of business. The orientation is quite different. Even at universities with rapidly growing data communications needs, voice communications represent eighty percent or more of the total telecommunications bill.

3. Have the consultant take a close look at what you are doing now and discuss with you what the options are.

Even if you have a well-managed system, an outsider's view can often improve your operation. Some specific areas to look at are:

a) Identify costs and procedures - it is difficult to know where to go if you don't know where you are.

b) Inventory of equipment - Ma Bell has a habit of charging you for phones you don't have. A conservative estimate is ten percent. In a three thousand-line system, that's thirty per month at $20.00 a whack - it translates into $600.00 per month or $7,200 annually.

c) Cable plans - these are often non-existent and you may find that the ducts are so choked off that any significant addition to the number of lines will require major construction. Ask how old your cable is and if it is direct buried or in conduit. If it's old and direct buried, chances are you're losing service to some extent every time it rains or someone uses a backhoe.

d) Long-distance costs - are you using an automatic route selection system (ARS) and is it engineered to provide the most traffic for your money? Would it pay to use DDD (Direct Distance Dialing) after hours and on weekends? This area is very complex and is usually where the most money is wasted. However, it is the easiest to correct if you know how.

e) Local message unit billing - some areas have gone to this (or have re-adopted it) for local calls and some older telephone systems cannot give you any detail as to who used how much each month. Unless you charge people internally for the usage of the system, abuse is invited. Message unit charges on local calls can mount quickly.

f) General feedback as to how well you are delivering your service - I discovered that, next to the seventeen digits people have to dial to utilize our long-distance routing system, the second largest number of complaints related to an individual in my operation.

You may decide that the system you have currently is adequate, dependable and economical and you have no need to look at changing systems for a few years. Much of your decision will depend on the area of the country you're in; the type of system you have now; your voice and data needs.

4. If you decide to explore the option of a new system, use the consultant to help you write the RFP. Let them interview a broad selection of your heavy users, critical users and special need users. (Skilled interviewers can use indirect

questions to get information.) You want to go to as many single-line phones as possible. This can be a real problem if you understand that people view key sets (the five buttons and the "hold" button) as a status symbol. Have them compile a draft of the RFP for your review.

5. In writing the RFP, the institution needs to make the following decisions:

    a) Where to locate the PBX (private branch exchange) - this will affect the engineering of the system. You are well-advised to locate it in the midst of the heaviest concentration of phones to minimize long runs of cable. Because new PBX's are computers, it is advisable to keep them away from water pipes, condensate pipes, steam pipes and steam pits. For the purpose of the bidding process, indicate a location so that cabling requirements will be equal for all vendors and prices will be comparable.

    b) Whether or not to insist on all new cable that is encased in conduit - the BOC (Bell Operating Company) will try to get you to reuse old cable. This is not an economy if you don't know where it is, its condition and if your service currently suffers because of weather or poor engineering. Also, using old cable results in "flash" rather than "parallel" cutover, which is much more painful. PBX vendors will not guarantee old cable and finger-pointing inevitably results when old cable is used and problems occur.

    c) How much additional cable building-to-building to request. Insist on additional cable (in conduit) building-to-building of fifty percent more than needed at cutover. This will allow for growth and unusable cable pairs. It's cheaper to put it in now than later. Also, some pairs can be used for alarm circuits, data connections, etc., which you are now renting from the phone company.

    d) How to accommodate technological advances which are not foreseen - ask for a price on additional conduit with pull wires to accommodate any sudden upgrade in technology. It's cheaper to do this when trenches are open. If someone suddenly finds the money to put in coaxial or fiber optic cable, you have the conduit all ready.

    e) How much additional capacity to wire in - insist on additional wired capacity (within the buildings) of ten percent or one year's growth. Don't buy any more than you need, especially if you're not expanding.

f) Ask for detailed engineering plans with the bid to assure that site visits have been made and that the price is in the ball park. Some companies will not make site visits and their bids are worthless.

g) How to accommodate ledge - and the resulting blasting - ask them whether or not their outside cable plant price includes ledge or some percentage. If not, ask for prices for thirty percent, fifty percent and seventy percent ledge. This is really important if you live in places like the Granite State.

h) Make the vendors break out ("unbundle") their prices - many of them won't unless you ask them to do this, and it is absolutely essential to be able to identify the various component prices in order to make valid comparisons between vendors. It is enlightening to compare what options are included in the base bid.

i) How to manage the project - unless you have a lot of "free" time in your mechanical trades or grounds departments, as well as your telecommunications department, insist on a total turn-key project. The vendor should be required to give you a seasoned project manager. Don't let someone earn his/her spurs on your project. Ask for resumes and references.

This is not to say that you should not have your own project manager, usually the telecommunications manager. Vendors will cut every corner possible otherwise. The point is that the vendor has the responsibility to hire (and stand behind) any subcontractors, which will leave you time to keep a close watch on the vendor.

j) How to accommodate data communications, as well as television, etc., - work closely with your data communications people (you'd be surprised how often this is not done) to get their future plans clearly in mind and to get data on what is already out there in terms of terminals (often, the only numbers a computer center has are for hard-wired terminals. They don't know how many dial-up terminals are out there.) Not all communication from terminals/mini's/micro's needs to go through the switch. Much of it can be accommodated with hard-wiring and local area networks (LAN's), but you need numbers.

k) Whether or not to include residence halls - this can often be a siren song for the unwary. Unless you have significant staff and foolproof methods of collecting past due accounts, you would be well-advised to avoid it. UNH has chosen to put in extra conduit with pull-wires in case we decide to resell to the students in the future.

l) Whether or not you wish to continue with direct inward dialing or to acquire it - if you currently have DID, chances are you'll want to continue with it. If you are currently on Centrex, your central office may be unable to give you DID on anything without an expensive upgrade that will take forever.

m) Who will construct the database once the bid is awarded - some of the newer companies are totally incapable of doing this and you may get stuck with this or have to hire a consultant to do it. Be sure to specify that the construction of the database will be the vendor's responsibility. You will sign off and do spot checks, but the vendor must go out there and count.

n) How much horsepower do you need? - don't buy a state-of-the-art system if your needs are not sophisticated. By the time your needs become sophisticated, that state-of-the-art system may be obsolete. This can end up costing you money. Resale isn't all it's cracked up to be. You may be well-advised to let the BOC handle student phones itself.

6. Establish an ad hoc committee which is representative of the major users on campus:

The amount of direct involvement will vary from campus to campus and among individuals on the committee. UNH's committee represented the following areas:

Director of Administrative Services (Chair)
Telecommunications Manager
Associate Director of Computer Services
Associate Director of Purchasing
Assistant Controller
Director of Facilities
Two Representatives of the Dean's Conference
Two faculty members
A representative of the Public Television Station
Associate Director of Development
A student affairs representative
A representative of the senior secretaries

The committee members reviewed the drafts of the RFP, and established the evaluation criteria. The consultants were responsible for all analyses and presented their findings to the committee, answering any questions and/or concerns.

Run some news articles on the committee and its members, in order to allow the various constituencies to identify their representatives and refer questions to them. The committee does not necessarily need to meet frequently, but the input from various sectors of the campus community is invaluable.

7. Unless you are a private institution and can choose which vendors you wish to allow to bid on your system, construct your bid specifications very tightly:

   UNH, like most public institutions, has a completely open bid process. (This is unheard of in the telecommunications industry and we had vendors reading their competitors' bids and taking notes for weeks). This leaves one no room for negotiation, so a carefully constructed set of specs can help the institution eliminate vendors who cannot deliver what you need now.

8. Ask for a list of colleges and universities where the vendors have installed the same switch in roughly the same line size and with the same data needs:

   Get names and phone numbers and arrange a lengthy telephone conversation at the very least. Site visits are preferable. You want to think carefully before agreeing to become a "beta test site".

9. Since the colleges/universities may not be in your service area, ask for a list of installations in your area and contact persons and call and/or visit:

   A switch is only as good as its maintenance. See how the customers like it.

10. How much will annual maintenance cost after the warranty period (one year?):

    Will it include on-site technicians and will they do moves and changes in their spare time? Moves and changes can be costly and it's crazy to pay for it if you have a technician twiddling his thumbs.

11. Where will training take place for the users?

    Be sure it takes place on-campus and that you can design the size and composition of the groups. Insist that working telephones be used. People (especially faculty) will not go to another town for training. You'll be lucky to get everyone to attend when it's on-campus.

12. Establish your evaluative criteria before the bids come in:

    We used three general areas:

    System characteristics
    Vendor qualifications
    Cost

    A total of one hundred points was distributed across these three sub-groups. Each group had eight to ten items which were assigned points. Systems were rated on a scale of one to ten as to whether or not they met each criterion; the score was then multiplied by the weight, to give a weighted score. Weighted scores were then totalled. The consultants were used to doing this, based on our discussions in committee.

13. There is no such animal as a bid that answers all specifications explicitly:

After the bid specs go out, meet with each vendor separately to answer any of their questions. After the bid deadline, arrange for your consultant and the committee to meet with each vendor to go over bids, to clarify questions, etc. One-half day per vendor is suggested in both instances. It is also recommended that each vendor be questioned alone; they are much more forthcoming when the competition is not around.

14. Based on written responses to the questions posed in the sessions, it is now possible to run through the technical matrices and the discounted cash flows:

This is something the consultant should be prepared to do for you. In the discounted cash flows, be sure to include all costs; including cable plant, the PBX, phones, all other equipment, maintenance after warranty, trunk cost/access charges and insurance. Costs are then computed on an annual basis with inflation built in over a selected time horizon (five, seven, ten years) and includes an interest factor if the system is not purchased outright. These costs are then discounted at whatever interest you could earn on that money today to give you a net present value (what the system costs over its lifetime expressed in current dollars). The low responsive bidder is compared with a similar cash flow on your current system to determine the economic feasibility of the new system.

15. Educate your key campus administrators as you progress:

There is something to be said for including any others in that process (system officers, key trustees) to head off the instinctive discomfort that results when you recommend a non-Bell vendor. Most people really believe Andy Griffith when he says "you don't have to change anything", and will balk at the thought of changing to an interconnect.

16. Do not underestimate the capacity of any vendor, but especially the local BOC or ATTIS for political jockeying behind the scenes:

The BOC's don't want to lose any installed base - they have the subsidy from long-distance revenues that kept them solvent in the past, but it is due to be phased out. In its place are access charges (charges to access the long distance network) and consumer groups are already lobbying Congress to keep residential rates down by deferring the access charges for residences indefinitely. That leaves business, industry, education and government to produce revenue. The BOC isn't going to let you go easily.

ATTIS, (nee American Bell) has a wonderful new system which will not be installed anywhere until the first quarter of 1985. But they will bombard you with all sorts of reasons for waiting. Meanwhile, you're paying high tech prices for out-dated telephony.

17. Take your consultant to the contract negotiation:

Better yet, let him/her do it for you. There isn't a telephone company (interconnect or Bell-type) that ever comes to the negotiation with anyone who can make a final decision. Consequently, the process is endless and frustrating. If you were enthusiastic about the vendor of choice before contract negotiations, you will hate him afterward.

In addition to short-circuiting the game-playing, the consultant has more power than you do for the simple reason that she/he makes a living recommending vendors and there is always a next time. So vendors are cautious about playing too fast and loose with consultants.

Coping with Asbestos

By John Skubal and Harold Harp
Johnson County Community College

Probably no single problem causes a physical plant manager as much anxiety as that of asbestos. From the discovery of the problem to the identification of the severity of the problem, to the arrival of a decision determining how to handle the situation, to communication with the staff and the public, the asbestos problem can assume dimensions of a full time job for several staff members.

It is with this in mind that we believe that our experience at Johnson County Community College with asbestos, its discovery, evaluation, and subsequent removal will prove beneficial to other managers facing such a situation.

Introduction

Johnson County Community College was constructed in 1971-72, and during the construction of the campus, concern was expressed over the exposed concrete pan ceilings in two of the buildings--the Educational Media Center (EMC), a three-story building housing, of course, the library, audio-visual department, graphics department, and the College printing department; and the College Commons, again a three-story building, this one housing the traditional student center, cafeteria, and a variety of meeting rooms.

The concern over the exposed concrete pan ceilings in these buildings was directed toward the acoustical characteristics of the rooms and the inability to achieve uniform illumination for areas where fixtures were recessed into the concrete ceiling pans. The architectural firm of Marshall and Brown was consulted. After consideration of a variety of materials, they arrived at the solution that was in existence until 1983. At the time, both the material and the application were acceptable in the industry, and while asbestos was used in a number of building materials, the levels contained in the application were not thought to be harmful. Since then, extended research has raised questions concerning whether there is a safe level and what standards should be used to determine that level. The various research data available led to different conclusions depending on each situation.

Background

In August of 1979, the United States Environmental Agency distributed booklets that alerted school administrators to the possibility of asbestos existing in school buildings that were constructed prior to 1975. It was recommended that visual inspections be made and tests conducted on questionable ceiling materials to determine if asbestos did or did not exist. After making visual inspections and conferring with the Director of Facilities, Gene Haun, we decided that laboratory tests should be made. Mr. Haun took two samples which were sent to Walter C. McCrone Associates, Inc., through the architectural firm of Marshall and Brown. After the reports were received from the McCrone laboratory, OSHA officials were informed of the findings, and although they were more concerned with industrial safety standards, they verbally issued the guideline that little concern was necessary if the asbestos content was below 10 percent.

The report was forwarded to the attention of Gene Haun at the College on November 15, 1979, and stated that asbestos was present in the chrysotile form at levels of .3 percent to 5 percent. We then contacted the United States Environmental Agency regional office to request their assistance in determining if there was a potential problem. On March 11, 1979, Wolfgang Brandner, Regional Asbestos Coordinator, visited the campus and visually inspected the Gym, EMC, and Commons buildings that contained the ceiling material tested. In a report dated April 3, 1979, from Mr. Brandner, "suggestions" to assist the College were made to help eliminate exposure to the asbestos fibers. The suggestions and resulting procedures to comply with these suggestions are as follow:

1. A frequent ceiling inspection should be instituted. A quarterly written report of the inspections was made by John Skubal.

2. High Efficiency Particulate Absolute (HEPA) vacuums should be purchased and used on carpet and furniture. The recommended vacuums were purchased and used in the carpeted areas of the Commons and EMC buildings. The hard surface floor of the Gym was damp mopped.

3. Maintenance and Custodial employees should be made aware of the potential problem and protect themselves when working on the ceilings.

4. Recommendations on "encapsulating" the fibers were made. This would not rid the buildings of the material but was an option.

5. Complete removal of the material would eliminate any potential problem.

6. Repairs should be made to damaged areas. It was determined that loose portions of the ceiling should be removed and disposed of properly, but repairs should not be attempted since the potential of fiber release exists any time work is done in these areas.

As College officials looked for assistance in solving the problem, consultations were made with Wolfgang Brandner and Frank Slezak, Environmental Protection Agency; Dale Sailors and Charles Stafford, State

Department of Human Resources dealing with industrial safety and health; William S. Kerbel, Environmental Scientist with the United States Testing Company, Hoboken, New Jersey; Reginald C. Jordan, Manager, Quality Assurance and Environmental Monitoring Programs, Northrop Services, Inc., in Triangle Park, North Carolina; as well as the research document prepared as a part of the Federal Register, dated Thursday, May 27, 1982, Part IV, titled "Friable Asbestos Containing Materials in Schools: Identification and Notification."

The ceiling material was monitored during the period between August, 1980, until December, 1982. The Environmental Protection Agency was notified and responded in January with a visit from Mr. Brandner, who then advised that the ceiling material should be retested to be certain of the content before a removal process began in Commons 252 and 260. Samples were sent by the College to Northrop Services, Inc., Triangle Park, North Carolina, as recommended by the EPA. The report from Northrop, dated March 10, 1983, #4240-83-2-1312, was received by the College on March 15, 1983. A summary indicated the sample from the Gym contained zero percent, from the Commons, two percent and from the EMC, four percent. Of the six commonly recognized asbestos fibers, chrysotile, amosite, crocidolite, anthophyllite, tremolite, and actinolite, the material sampled contained chrysotile asbestos, which is potentially less hazardous than the other fibers because of its chemical composition.

A list of contractors who had expressed willingness to perform asbestos removal work was supplied by the EPA, and from this list, "Advanced Insulation Service" of Merriam, Kansas, was contacted on February 10, 1983. Mike Porter visited the campus and visually inspected the areas that have ceiling material containing asbestos. A cost of $2-$3.50 per square foot was given as a guideline for estimating removal costs.

During the week of March 14, 1983, custodians initiated action to remove and bag some of the loose ceiling materials in Commons 252. Preferably the material should have been left alone; however, when it was discovered the material had been removed and scrapped, the Child Play Center was relocated from Commons 252 to Commons 319A. The Environmental Protection Agency was contacted, and Mr. Brandner met with Gene Haun, John Skubal and other College officials to discuss what procedures to follow. Mr. Brandner agreed the moving of the Child Play Center was proper and that the area should be closed until the disturbed ceiling material was removed. Mike Porter of Advanced Insulation was invited to meet with the group and discuss his removal technique which is as follows: (1) enclose the area with 6 mil. plastic, (2) wet the ceiling material, (3) scrape the materials from the ceiling, (4) pressure spray the loose material, (5) allow the ceiling to dry, and (6) spray on and tape K13 ceiling finish.

Mr. Brandner agreed that this was an accepted Environmental Protection Agency procedure. Mr. Porter was asked to formalize his proposal in writing including a price and timetable. Two area firms, Judy Company of Kansas City, Kansas, and Fairlie Industrial Insulation were also asked to submit proposals as outlined above.

John Skubal was contacted by Mr. Sailor of the Kansas State Health and Safety Department who asked if they could be of assistance with the asbestos problem. When Mr. Sailor was informed of the contractors submitting proposals, he stated that all had performed satisfactory work in state owned buildings or schools and approved the selection of potential contractors.

Statement of Problem

In the areas listed on the attached sheet, the College determined through laboratory tests that they contain low levels of asbestos. Some of the areas showed no signs of delaminating or peeling; other areas were peeling or delaminating. In some areas, a solution could have been to encapsulate the material. This offered a long term but not total solution. If the asbestos were not removed, the same issues raised then would be raised anytime the ceiling required work. For example, to anchor track lighting in an area known to contain asbestos, it would be necessary to disturb the encapsulated particles if drilling or pounding anchors into the surface was required.

Recommendations

Our problem had two solutions. The first was total removal and resurfacing of the affected ceiling. The second solution would be to encapsulate areas which would not lend themselves to this method. While the cost of total removal of the asbestos was much greater (2:0), it offered an environment that would create no further problems. Encapsulation was a process that had worked and, in certain areas of the College, would keep friable materials from escaping into the air. Work could not be allowed on the ceiling where encapsulation was used due to the problem of allowing the fibers to be disturbed and subsequently become airborne.

A list of criteria was established to aid in the evaluation and enable the College to proceed on a systematic schedule. This schedule would not disturb ongoing instructional activities and would deal with the perceived problem within a financial and logistical timeframe. The criteria used to aid in the evaluation for establishing priority listing are as follow:

1. Small confined areas with heavy density of population.

2. Areas where ceiling material may be disturbed by air erosion or people coming in contact through moving of equipment.

3. Areas with delamination of existing material causing the material to become airborne with the potential of friable asbestos particles being discharged.

4. Areas with extended hours of confined occupancy.

5. Areas treated in most logical order of efficiency.

The work schedule for the Commons was financed from the maintenance bond reserve that was currently available for those necessary repairs associated with the building and its related equipment. The balance could be financed from either the General Fund or the Special Building Fund. If it was financed from the General Fund, it would be possible to spread the expense over two budget years.

Based on the previous criteria, a schedule of activities presented for consideration and listed in a descending order of priority would be as follows:

1. Commons 2.5 including Room 252 (Child Play Center, Room 260, and the entrance areas to each room.
   Estimated Cost: $10,000 Start Time: 3-28-83

2. EMC 154, 156, 156A, 156B (Includes TV Studios and related areas)
   Estimated Cost: $50,000 Start Time: 5-16-83

3. Commons 1.5 and 2.0 levels
   Estimated Cost: $90,000 Start Time: 5-23-83

4. Basement of Commons
   Estimated Cost: $17,000 Start Time: 6-20-83

5. EMC 1st and 2nd Floors
   Estimated Cost: $300,000 Start Time: 7-5-83

6. Gym Lobby
   Estimated Cost: $24,000 Start Time: 8-1-83

7. EMC 3rd Floor (Includes Print Shop, Mailroom and Hallway)
   Estimated Cost: $268,000 Start Time: 8-8-83

These estimates were high and like all estimates should be treated with confidentially to avoid influencing future bidding from potential contractors.

Cost from Maintenance Reserve Fund:	$117,000
Cost from General Fund and/or Special Building Fund:	642,000
TOTAL	$759,000

Bids were received for Item #1, and it was recommended that bids be solicited for the Board of Trustees' review and approval for Items #2, #3 and #4. Items #5, #6 and #7 were monitored and reviewed to determine the most effective manner to deal with the remaining areas of concern.

Summary

The guidelines established to govern colleges and universities are limited in scope and do not define process or priority. Johnson County Community College was not mandated or in violation of any known federal, state or local law or legislation to take any further action on the problem. While the research on the potential danger of people coming in contact with asbestos is conclusive, it is still subject to many varied interpretations as to the levels of danger and exposure.

The possible overreaction of a few concerned employees can generate fear for not only the people working in these areas of concern, but also for those whose lives are not affected by their office or classroom setting. Asbestos is a common material used in some construction material, and it should be recognized that the presence of asbestos is not the problem, but when it is friable and becomes airborne, it may pose a potential hazard. Some government officials orally expressed the view that the air quality in Kansas City may potentially be of a higher contamination level than students or staff were ever exposed to at the College. At any rate, a straightforward communication with all staff should be a matter of priority to alleviate real or imagined concerns, and it should contain an explanation of the nature of the problem, what solution was chosen, how it will be accomplished. This initial communication should then be followed up with periodic progress reports.

Environmental officials expressed the feeling that the pro active role taken by the College was commendable, and the process established to date and anticipated in the future was one that will alleviate any future problems regarding the ceiling materials.

For your consideration, we are including the bid-spec we used which was prepared by John Skubal with the assistance of the EPA. Any or all of the specifications may be used by any who so desire.

JOHNSON COUNTY COMMUNITY COLLEGE
REMOVAL OF ASBESTOS MATERIALS

PROJECT DESCRIPTION AND SCOPE

Work specified under this section includes complete removal of all asbestos materials in the specified area. Work will be located in the basement and 2nd floor of the College Commons and the 1st floor of the Gymnasium (see enclosed mark COM 0, COM 2/2.5 and and GYM 1). It is the contractor's responsibility to visit the job site. Inspections of the area shall be scheduled through the Office of Facility Planning and Management. Contact John Skubal, 888-8500 X810, to arrange for an inspection. The College will not accept bids from contractors who have not visited the job site and registered in the Office of Facility, Planning and Management. NO EXCEPTIONS. College provided measurements that are a part of this or any other document are to be verified by the contractor. The College accepts no responsibility as to the accuracy of the measurements.

The Contractor is hereby advised this is an asbestos removal project and he must comply with all OSHA and EPA regulations that pertain to this type of work, whether specifically stated or implied in these Specifications.

Before starting any removal work, the Contractor shall notify the EPA and submit his method of removal to them for approval before proceeding. A copy of the written approval shall be forwarded to the College Office of Facility Planning and Management for review and approval before work is started.

TERMS AND CONDITIONS

Submission of Bids

Sealed bids for the removal of asbestos as described in the specifications herein will be received at Room 101 Campus Services Building, Johnson County Community College, College Boulevard at Quivira Road, Overland Park, Kansas, 66210, until 2:00 p.m. on November 17, 1983 and will be publicly opened and read aloud. Bids received after time and date stated will be returned unopened.

Bids shall be submitted on the bid sheets provided in the bid document; all appropriate blank spaces shall be completed. The words "No Bid" are to be written in the blank spaces for those areas in which no bid is being submitted. Bids shall be stated in both writing and figures. In case of any discrepancy in the amounts shown in the bid document and unit prices shown on the drawings included in each package, the amounts expressed in words in the bid document shall govern.

If the bidder is a corporation, the bid shall contain the legal name of the corporation and shall be signed by the duly authorized officer, the corporate seal affixed; if a partnership, it shall be signed by one of the partners authorized to execute documents and shall give the names and addresses of all partners.

Award of Contract

Johnson County Community College reserves the right to reject any or all bids, the right to waive irregularities in any bid, and the right to make award in the best interest of the College. The successful bidder shall execute a performance bond in the full amount of the contract sum. The Board of Trustees is scheduled to take official action on the award of this bid at their December 19, 1983, Board meeting. However, the staff will notify the anticipated successful contractor of the recommendation for award of the contract prior to December 1, 1983.

Bidders who are being considered for award of this project may be required to file a statement of qualifications and ability, financial and professional, to perform the work described within this bid. The statement may include the following:

a) List of current work of comparable nature, including location and person to contact in reference to the project.
b) Current financial statement and bank reference.
c) Supplemental information pertinent to complete projects of similar work.

Johnson County Community College reserves the right to limit the bidders to those who can submit evidence of experiences and ability to perform the project in the time frame and scope as detailed to the satisfaction of the designer and construction manager.

Insurance

The successful contractor (s) is to provide certificates of insurance evidencing Worker's Compensation in accordance with the State of Kansas laws; General Liability (including Contractor's Liability); Auto Liability with minimum limits of $1,000,000; and property damage of not less than $1,000,000. The required signed certificate is to be delivered to the Purchasing office prior to the start of any work on campus.

Tax Exemption

Johnson County Community College is exempt from tax levied by the Kansas Retailers' Sales or Compensating Tax Act. Tax exemption certificates will be issued by the College when requested by the Contractor for items which will fall within the scope of the contract (s), and may be properly exempt from such taxes.

Payments and Project Acceptance

Payment for all work performed under this contract will be made in cash by the College within thirty days after receipt of invoice. The Manager of Campus Services for JCCC will officially accept the construction and installation of the project and will approve all invoices for payment.

Permits and Compliance

It is the responsibility of the successful contractor to obtain all necessary permits at no cost to the College. It is understood that the contractor will comply with all applicable local, state and federal codes, including federal regulations pertaining to prevailing wages.

EEOC

The following (Sect. 1-5 of K.S.A. 44-1030) are conditions of this project. Only contractors, vendors or suppliers whose cumulative dollar total in any fiscal year is $5,000 or less, or who have fewer than four (4) employees shall be exempt.

1. The contractor shall observe the provisions of the Kansas Act against discrimination and shall not discriminate against any person in the per-formance or work under the present contract because of race, religion, color, sex, physical handicap unrelated to such person's ability to engage in the particular work, national origin or ancestry;

2. In all solicitations or advertisements for employees, the contractor shall include the phrase, "equal opportunity employer," or a similar phrase to be approved by the commission;

3. If the contractor fails to comply with the manner in which the contractor reports to the commission in accordance with the provisions of K.S.A. 1976 Supp. 44-1030, as amended, the contractor shall be deemed to have breached the present contract and it may be cancelled, terminated or suspended, in whole or in part, by the contracting agency;

4. If the contractor is found guilty of a violation of the Kansas Act against discrimination under a decision or order of the commission which has become final, the contractor shall be deemed to have breached the present contract and it may be cancelled, terminated or suspended, in whole or in part, by the College; and

5. The contractor shall include the provisions of paragraphs 1-4 inclusively of this subsection in every subcontract or purchase order so that such provisions will be binding upon such subcontractor or vendor.

SPECIFICATIONS

A. Worker Protection

(a) It is the Contractor's responsibility to have checkups on his men to be sure they are in good physical health to wear the respirators.

(b) Contractor shall provide his men with the following:

1. Respirators shall be equal to "Comfo II" as approved by NIOSH and MSHA for respiratory protection against dust,

mists, fumes, etc. There shall be a sufficient supply of filters for the respirators to last the entire workday. Filters shall be stored at the jobsite in the change room and shall be totally protected against exposure to asbestos.

2. Respirators shall be properly fitted to each worker's face and all workers shall be properly trained in use of the respirators by the Contractor.

3. Wear disposable, full-body coveralls, disposable head covers, footwear and gloves. Footwear need not necessarily be disposable; if non-disposable footwear is used, it shall be left in the work area at all times.

4. Goggles shall be fog-proof type with indirect ventilation and must be able to accommodate eyeglasses.

5. Provide enough of the above items for College inspectors.

(c) All workers, without exception, shall:

1. Remove street clothes in the change room and put on the disposable coveralls, head covers and respirators before entering the work area.

2. Remove the disposable coveralls, head cover and footwear in the work area before leaving the work area. While still wearing the respirators, proceed to the showers and remove the respirators while showering with soap and water. Towels, soap, and hygienic conditions are the responsibility of the Contractor.

3. Shower at the end of each day's work before entering the change room to change into street clothes.

(d) Proper procedure for donning work clothes:

1. Head cover.

2. Respirators.

3. Hooded coveralls.

4. Foot coverings.

5. Gloves.

6. Eye protection.

(e) Proper removal of work clothes shall be the reverse of the above procedure.

(f) Workers shall not eat, drink, smoke, chew gum or chew tobacco in the work area. To do any of these, workers shall remove the disposable work clothes and footwear in the work area before leaving the area. While still wearing the respirators, workers shall proceed to the showers and remove their respirators while showering with soap and water. Workers shall then dress into new, clean disposable coveralls to eat, drink or smoke. The new coveralls can be worn to reenter the work area.

(g) For each work area, Contractor shall provide two (2) five-gallon carbon dioxide fire extinguishers suitable for Class "A", "B" and "C" fires.

B. Work Area Preparation by Contractor:

(a) The following items of area preperation shall be performed on the ceilings prior to asbestos removal:

1. Contractor shall set up a decontamination facility outside the work area, consisting of the following:

   a. Change room.
   b. Shower area.
   c. Equipment area.

2. Location of the decontamination facilities shall be adjacent to work areas.

3. Bring into work area any scaffolding, ladders or other large pieces of equipment before erecting plastic barriers.

4. Contractor shall damp-clean and wrap with four-mil polyethylene film all immovable laundry equipment indicated on the drawings. Tape all edges and seams.

5. Contractor shall construct double barriers (air locks) of plastic sheeting at all entrances and exits to the work area so the area is always closed off by one (1) barrier when workers enter or exit.

6. All ducts, vents, registers, etc. shall be sealed with plastic and taped at edges full length and width. Remove all heating, ventilating and air conditioning system filters, packing them in sealable plastic bags (six-mil minimum) for burial with other waste. Replacement of filters will be done by the College.

7. Contractor shall seal and tape electrical outlets, junction boxes, breaker boxes, and electrical wires.

8. Cover floor with at least two (2) layers of six-mil polyethylene sheets, bringing sheets at least 2'-0" up on wall and taping seams. Lap sheet seams, roll over and tape together to ensure watertight seams. Heat welding will be acceptable.

9. Cover walls with four-mil polyethylene sheets, taping at ceiling. Lap over and tape where wall and floor sheets meet. Lap sheet seams, roll over and tape together at joints.

10. Contractor shall establish emergency and fire exits from work area. Emergency procedures have priority.

11. Post the following sign at all entrances to the work area:

LEGEND	**NOTATION**
ASBESTOS	1" block
DUST HAZARD	3/4" block
AVOID BREATHING DUST	1/4 gothic
WEAR ASSIGNED PROTECTIVE EQUIPMENT	1/4" gothic
DO NOT REMAIN IN AREA UNLESS YOUR WORK REQUIRES IT	1/4" gothic

12. The Contractor will be liable for any damage that results from this project. No payment will be made by JCCC until all damage is repaired to the College's satisfaction by the Contractor.

C. Asbestos Removal:

(a) Asbestos material shall be sprayed with amended water. Wetting agent or additive shall be 50% polyoxyethylene esters and 50% polyoxyethylene ether, "AquaGro" or approved equal, using one (1) ounce "Aqua-Gro" to five (5) gallons of water. A fine spray of this solution must be applied to prevent fiber disturbance preceding removal of the asbestos material. The asbestos shall be sufficiently saturated to prevent emission of airborne fibers in excess of the exposure limits prescribed in the OSHA Standards (Section 1910.1001.b.) Allow wetted asbestos to set twenty-four (24) hours before removal.

(b) Material shall be packed into labeled six-mil plastic bags held within fifty-five (55) gallon fiber drums for transporting to burial site. The outside of all containers shall be cleaned before leaving the work area.

(c) Packed and sealed drums shall be delivered to the burial site bearing all necessary labels and signs in accordance with EPA and OSHA Standards. These labels and signs shall be purchased by the Contractor. All plastic sheeting, tape, cleaning materials, clothing and all other disposable materials or items used in the work area shall be packed into plastic bags, placed in drums and labeled for transporting to the burial site.

D. Ceiling Area Refinishing

(a) Before the ceiling area is refinished, the College will inspect and approve the removal process. If, in the opinion of the designated College personnel, the ceiling is not fully free of any asbestos content, the area must be recleaned. No refinishing may be started until this approval is received. NO EXCEPTION.

(b) The refinishing shall be tamped K-13, or an approved substitute, sprayed over the entire ceiling, in all areas but excluding the entrance to west stairwell of Commons Building which will be left bare.

E. Air Monitoring

(a) Air monitoring must be accomplished in accordance with the field operations manual for industrial hygiene, USDOL - OSHA.

(b) Prior to application of the new wall treatment and removal of protective materials from the work area, additional samples must be collected outside the work area in accordance with EPA recommendations to determine containment during removal.

(c) The Contractor shall provide the College with a copy of laboratory results for each air sample taken.

(d) The Owner reserves the right to have his own air samples taken at any time during the removal and cleaning operation, at his own expense.

F. Work Area Clean-Up

(a) After asbestos is removed, remove film from walls and floor and fold over to contain all debris. Plastic sheets shall be put into properly marked bags, placed in drums, sealed and removed with other waste material.

(b) Damp mop floors and wash down walls with wetting agent where practical and vacuum areas with a high-efficiency particulate absolute (HEPA) filtered vacuum. Allow twenty-four (24) hours for dust to settle, then wet clean and vacuum surfaces again. Contractor shall perform a complete visual inspection of the work area to ensure it is dust-free after cleaning. Two (2) air samples shall be taken within forty-eight (48) hours after completion of all clean-up work (minimum volume of air is 240 liters).

(c) If the work area is found to be unsatisfactorily decontaminated, Contractor shall repeat the cleaning and air monitoring until it is in compliance.

(d) When the area is found to be in compliance, all entrances and exits shall be unsealed and plastic and tape shall be disposed of along with the other debris.

G. Disposal of Waste Material:

(a) Before disposing of waste materials, Contractor must receive permission from the local landfill to dispose of the waste.

(b) Contractor shall transport the sealed drums to the approved waste disposal site. Sealed plastic bags may be dumped from the drums into the burial site unless the bags have been broken or damaged. The damaged bags shall be left in the drums and the entire contaminated drums shall be buried.

(c) Workers unloading the drums, as well as machinery operators, shall wear respirators.

(d) Burning of materials removed from demolished areas will not be permitted on the site.

Overcoming The PCB Hurdles

By C. R. Nuss
University of Washington

"Impossible!" or "Send in the Budget Request and let THEM come up with the answer" seem to be common management approaches to handling Federal PCB regulations.

Time and experience are showing that many organizations, including Institutions of Higher Education, are not sufficiently aware of the requirements and consequences of the Toxic Substances Control Act. A typical response is to estimate, then forward the cost impact of PCB equipment replacement to the funding source. This usually is so overwhelming that very little is, nor can be, done.

But in fact, a great deal can and must be done--in the interim before final removal from your premises.

We seem to have become accustomed to having limits or ranges within which other types of pollution are regulated; such as in the Clean Water Act, Emissions Standards, and Noise Control regulations. PCB regulations have one noteworthy feature that is in contrast to those of others--anything above zero is a violation!

The University of Washington was cited for regulatory problems soon after regulations went into effect. Rather than contribute tens of thousands of dollars to the Federal general fund, to no benefit of the environment or to other institutions that may face the same fines, an equivalent amount was spent on a project that is intended to address and contribute directly to meeting environmental concerns.

A video tape has been prepared which reviews the problems and issues and presents some ideas for dealing with ownership of PCBs. Part of the charge is to make the tape available for groups such as APPA. The purpose is to assist you. Anyone interested in acquiring copies of the tape, either 1/2" or 3/4" is welcome to contact me at (206) 545-1479.

The text of the tape follows:

PCBs--Polychlorinated Biphenyls--although long and seemingly complex, the name readily describes the basic structure of this group of molecules--two six-carbon phenyl rings with chlorine atoms so tightly bonded to them that the whole molecule becomes extremely stable. The numbers of chlorine atoms and the sites at which they are attached or bonded determine the special PCB type.

PCBs may have slightly different characteristics due to variations in the number of bound chlorine atoms and differences in their bonding sites. Thus, various PCB can vary in physical properties such as viscosity. For example, PCBs range in consistency from waxy solids to oily fluids.

PCBs were first synthesized in 1929 and were discovered to have several qualities that subsequently made them quite valuable commercially. PCBs mix easily with oils. They do not conduct electricity. They are extremely stable--so stable that they burn only in conditions of extreme temperature and abundant oxygen. In normal environmental conditions they break down so slowly that they may be considered permanent. In short, they are a very good choice when you must subject substances to extremes of temperature, pressure and electric charge without having them break down and lose their effectiveness.

These qualities have led to wide use of PCBs for a variety of applications. Their insulating qualities make them valuable for use in electrical equipment where they may also carry off heat that could damage sensitive components. Their stability makes them valuable in high pressure hydraulic systems, in heat transfer systems, and for mounting microscopic specimens. They are also useful as stabilizers and plasticisers in paints, dyes and plastics and for a wide variety of other applications.

In the last twenty years there has been a growing awareness of an additional ominous characteristic of this family of molecules.

Stable and attracted to oils and fats--if they find their way into the environment they are picked up and stored by the elements of the environment that contain oils and fats--living cells. Here PCBs show a more sinister side of their character--they are toxic!

The toxic effects of PCBs on living things appears to vary with the dose and the organism. Some organisms show no effects, even in the presence of fairly high concentrations of PCB. Others are remarkably sensitive. Tests in laboratory animals have shown relatively small doses to cause a variety of disorders including skin lesions, reproductive failure, gastric disorders and tumors. Not only are the PCBs themselves toxic, but certain contaminants, called dibenzofurans, that are often formed during the manufacture or use of PCBs and therefore are commonly found with PCBs are even more toxic. Thus any entry of PCBs into the environment raises the possibility of the addition of this second toxin to the environment.

The effects of relatively high doses of these toxins on humans are also well documented. In 1968, on the Japanese island of Kyushu, rice oil was contaminated by PCB and probably also by dibenzofurans from a leaky heat exchanger. As might have been anticipated from the laboratory findings, the acute effects of this exposure on the people of Kyushu who consumed the oil included skin rashes and lesions, joint and abdominal pain, jaundice and lethargy. The long-term effects are still being studies. A similar event occurred on Taiwan in 1979 and the people that consumed the contaminated foods suffered much the same symptoms.

There have been other accidental releases of PCBs into the food chain and though not quite so dramatic as the Japanese and Taiwanese incidents, these events exemplify the risks and costs encountered when PCBs are inadvertently released into the environment. A leaking heat exchanger in North Carolina contaminated fish meal base for animal feed; a warehouse fire in Puerto Rico allowed PCBs from stored transformers to again contaminate fish meal stores; and a leaking transformer in a Montana packing company contaminated animal feed that was later used in several areas. Cleanup and corrective actions taken in these instances cost millions of dollars and did massive economic damage to the companies involved. If the spills had not been detected, moderate quantities of PCB would have found their way onto dinner tables throughout the country.

Because PCBs are extremely stable and break down so slowly in the environment; because PCBs tend to accumulate in body fats over time; and because there is little knowledge of the long term effects of exposure to PCB, it is difficult or impossible to establish a "safe level" of personal exposure. Many believe that there is no truly safe level of human exposure to PCBs. This is the position taken by the Environmental Protection Agency.

Similarly, there is no truly safe level of environmental exposure. PCBs accumulate in living cells, plants, bacteria, plankton, and their presence is magnified as these are consumed by creatures higher on the food chain--a process called biomagnification. The fish that eats plankton is accumulating PCBs from that source, and the fish, bird or mammal that eats that fish and his kind will concentrate the PCBs still further. Thus, even if there is a level of PCBs that has not been demonstrated to harm a given organism, there are no guarantees that, through biomagnification, organisms higher on the food chain, including humans, would not be harmed.

PCBs are already present in small quantities in all corners of the globe--from New York harbor to the Arctic and Antarctic. They are found in a variety of organisms in a variety of environments--in shellfish and seals, polar bears and penguins--and man.

PCBs are slowly removed from the biological environment by natural processes. They may bind to organic matter and be buried in sediments. If these sediments remain undisturbed long enough the PCBs in them will disappear through slow natural breakdown processes. These same breakdown processes also slowly remove unburied PCBs from the environment. Either way, if we do not replenish them, PCBs will, for all practical purposes, disappear from the environment over time.

There are alternatives to the use of PCBs that pose less risk to our environment and ourselves. By turning to these alternatives and by carefully guarding the environment from additional contamination from currently existing PCBs, we will allow the environment to purge itself of this toxin.

This then is the rational basis for Section 6e of the Toxic Substances Control Act of 1976. This law prohibits the manufacture of PCBs, prohibits the use of existing PCBs except in a totally enclosed manner, or if not totally enclosed, under very specific authorized conditions.

It also prohibits processing or reuse of PCBs and PCB contaminated equipment and articles without special authorization from the Environmental Protection Agency. Furthermore, the Toxic Substances Control Act required the Environmental Protection Agency to establish and enforce rules governing both the ban on manufacturing, processing, and distribution of PCBs and PCB equipment and the procedures for ensuring adequate monitoring, labeling, and disposal of PCBs, PCB equipment and PCB contaminated articles. The final EPA ban rule also banned import or export of PCBs after July 1979.

The EPA rule applies to any substance or material containing a substance with a concentration of PCBs that is 50 parts per million or greater. This is the equivalent of one milliliter (a few drops) of PCB in 20 liters (approximately 5 gallons) on non-PCB oil. Furthermore, under certain special circumstances such as those found in conjunction with the clean water act, concentrations of less than 50 parts per million are regulated.

The EPA rule has taken into account a number of factors regarding the potential impact of controlled PCB use; the legal mandate of the Toxic Substances Control Act; the negative effects of PCBs on human health and the environment; the potential magnitude of the exposure; the economic benefits to be derived from the continued controlled use of PCBs in certain situations; and the burden of managing the PCB problem to businesses, local economies and the national economy have all been considered in the formulation of the final rule.

Obviously because PCBs have been used for so many varied applications, from microscopic mounting medium to electromagnets, the final rule is somewhat complex. However, since two of the most common and generalized continuing uses of PCBs in quantity are in transformers and capacitors, we will focus on these pieces of equipment.

PCBs used as coolants and insulators in transformers and capacitors must be totally enclosed--that is, must have no avenue for escape into the environment. Leakage of quantities as small as a single drop must, by law, be contained, cleaned up, and the source repaired.

The EPA rule affects the users of this equipment in the following ways. All equipment that may contain PCBs must be inventoried to determine the nature of the equipment and the quantity and concentrations of PCB represented.

If the facility or institution owns more than 45 kilograms or 99.4 pounds of PCBs, one or more PCB transformers or 50 or more PCB capacitors, records must be kept that describe the items, their locations, inspections, leakage, repairs, and, when the items are finally disposed of, their disposition. These records must be updated annually and kept for a full five years after the disposal of the last of the PCB items.

Transformers that contain over 500 parts per million PCBs and large capacitors--those containing over three pounds of PCB--must be labeled to warn all personnel that may have contact with the equipment of its contents and potential dangers. The labels must meet very specific EPA standards. In fact, they must be exact replicas of those shown here and contain the emergency telephone number of the U. S. Coast Guard National Response Center.

The labels must be attached to the equipment, either directly or, when heat buildup causes the labels to peel, with aluminum plaques or a similar system.

In selected situations where labeling the equipment directly is impractical, labels on all routes to the equipment are permissible. Thus, when equipment such as a capacitor is located in a protected environment, such as on a power pole or behind a fence, the pole or fence may be labeled instead of the equipment. Labeling on both the entryway and equipment is preferable. If a previously protected but unlabeled item is removed from its isolated position it must be labeled. Labels must also be put on containers of PCBs in storage, containers for PCB cleanup articles, PCB cleanup articles, PCB equipment for disposal, and storage areas holding such equipment containers and articles.

Finally, vehicles used to transport PCBs must be labeled to alert emergency service personnel to the potential harm posed by damage to or a spill of the cargo.

PCB transformers containing 500 parts per million PCBs must be inspected for any signs of leakage at least every three months. If, however, the transformer is in an area in which its entire volume of fluid would be contained in the event of a massive leak, or if the transformer contains less than 500 PPM PCBs, inspections can be reduced to one per year.

By repeatedly separating, treating, and replacing the PCBs and PCB-contained fluids in transformers with non-PCB fluids, companies can reduce the PCB concentrations in PCB transformers dramatically. If the PCB concentrations can be brought below 500 PPM, the inspection schedule may be reduced from quarterly to yearly. The companies can also perform maintenance on transformers containing less than 500 PPM with minimum danger of environmental contamination or threat to human health.

Unfortunately, these decontamination processes are quite costly, and as such usually dependent on the economies of scale found only in very large organizations. Also, the replacement of PCBs with non-PCB fluids reduces the energy carrying capacity of certain transformer designs. Remember, PCBs were used because of their excellent characteristics in the heat and electrical environment of transformer use. Substituting other dielectric fluids in transformers designed for PCBs requires reducing the maximum operational loads that the transformer may carry; a process called derating.

All leaks must be recorded. Leaks that threaten to enter the environment due to their size or their location must be reported to the Coast Guard through the emergency number on the PCB label. Leaks must be contained and the clean up process must be initiated within 40 hours of the owner becoming aware of the leak. Leaking equipment must be inspected daily until it is repaired or replaced to ensure that the leaks are being contained. Successful repair of these leaks will allow the transformer to return to a quarterly or yearly inspection schedule, thus saving the owner time, paperwork and money.

Often repairs can be as straight forward as tightening valve and valve joints. If these maneuvers are impossible or impractical, the repair may be

373

done by cleaning and preparing the surface and using a special purpose cold weld substance that will tolerate the temperatures and chemistry of the transformer environment. One such substance, trade name Velodure, has been used extensively and successfully for this purpose.

All PCB-contaminated rags, absorbent materials, clothing, or other articles must be stored and disposed of as PCB items. Thus, they must be clearly labeled and dated or placed in labeled, dated containers. These may be stored only in specific protected, secure areas that are appropriately labeled. These areas must be able to prevent any potential leakage into the environment. They usually consist of an area of impermeable floor surface with a six inch high berm, or a pan that has a capacity to contain 200 percent of the internal volume of the largest container within the pan or 25 percent of the total internal volume of all of the PCB items stored.

It is also the responsibility of the PCB owner to ensure the proper disposal of all stored PCB items and, eventually, all of the PCBs in their possession. Obviously it is imperative to dispose of PCBs in such a way as to ensure that they will not enter the environment.

There are two major techniques for disposal of fluids containing PCBs, each with its advantages and limitations. PCB fluids in quantity can be chemically changed into readily eliminated or non-toxic constituents or bound to special disposable units. These processes are most often used by large industries, such as utilities, who may own large numbers of PCB-filled transformers. The chemical breakdown processes are often used after a transformer has initially been drained and flushed to bring the concentrations of PCBs below 5000 parts per million.

The second avenue of PCB disposal, the one most commonly practiced, is incineration. Given high enough temperatures, even PCBs are destroyed. The specialized waste incineration equipment must pass stringent EPA efficiency tests that include thorough stack emission tests. Fluids that contain over 500 parts per million PCBs and large PCB capacitors must be destroyed in these specialized incinerators. Fluids containing concentrations of less than 500 PPM PCBs may be burned in high-efficiency boilers that have passed stringent EPA criteria that prove their ability to destroy PCBs in these concentrations. Generally, incineration is the more accessible and practical means of disposal for institutions disposing of small quantities of PCB.

Finally, PCB equipment and PCB articles are most commonly disposed of in toxic waste landfills that have been approved for PCB disposal. All PCB items that might release their PCB contents such as contaminated rags, debris and leaking equipment, must be sealed in containers with sufficient absorbent material to immobilize any residual PCB contents should the container ever rupture. Although not required, it is considered prudent to seal ALL PCB items, even those that do not leak, that are scheduled for disposal in this manner.

The regulations and responsibilities associated with ownership of PCBs become a particularly vexing problem in institutions such as large universities. The very nature of a university environment, the collection of academics, administrators, support staff, large and small research facilities, and the physical plant to support all of this, makes the administration of compliance measures a great deal more complicated than in a comparably sized industrial setting. The lines of authority and communication in an academic environment tend to be less direct and more complex than in a comparably sized industry in which the products and goals are more distinct. As a result, violations of the PCB regulations are common in institutions of higher education throughout the nation. In these institutions there must be a greater awareness of the legal, fiscal and environmental consequences of non-compliance and of the need for internal education and training programs to combat the problem.

Not only do faculty, staff and administrators vary widely in their understanding or awareness of the PCB problem, the information and education efforts that are directed to these people must encompass numerous internal information channels including discipline-specific and general newsletters, special announcements and memos, seminars, workshops and special education sessions.

The bulk of the PCB sources in university settings, large transformers and capacitors, are managed through the physical plant staff or through major electronics-related research and education programs. This provides an opportunity to deliver education and control programs to a selected group of faculty and staff who have a great impact on achieving and maintaining compliance.

However, due to the multitude of projects, and diversity of faculty and staff, there is also the potential for small sources to be overlooked.

The University of Washington physical plant consists of over 200 buildings housing over 50,000 faculty, staff, and students. It is a city unto itself with heat and power facilities to match the needs. The electrical system was in place prior to EPAs PCB regulations, and all aspects of the regulatory program apply.

At the University of Washington many techniques are used to help identify points of non-compliance with the EPA rules and to find PCB sources that may have been overlooked in the complexity of the university environment. In addition to the educational efforts that are directed at physical plant and electronics research personnel, safety bulletins in various campus newsletters direct attention to the PCB problem, and the need to identify PCB sources and to provide information on how to identify and report potential sources. Memos and information lette[illegible]ith similar content are directed to departments that may have unidentified PCB sources. Safety management seminars for university administrators include information on recognition and reporting of potential PCB items. During these seminars, administrators are told how to identify and report potential PCB items to Environmental Health & Safety. They are also told that their department is legally responsible for compliance with the regulations, and given the conditions of compliance, and techniques for achieving these. Finally they are notified that failure to comply may lead to a fine payable by the department.

In addition to these information and education efforts that are directed to the users and administrators, education efforts directed toward maintenance personnel emphasize the identification and reporting of potential PCB items encountered during their routine maintenance duties. Thus, although in a large and diverse institution sources may initially be overlooked, constant attention eventually allows most of them to be documented and appropriately managed.

Compliance may sometimes seem difficult to achieve. Obviously, with the rules concerning enclosed use, ANY leak rate above zero constitutes a violation. Discovering these small leaks often requires very close scrutiny of large pieces of electrical equipment in close quarters. Once discovered, containment and repair of such leaks may require disruption of electrical service to important facilities.

Other problems include stains and "wet" spots caused by non-PCB oils and solvents that are commonly encountered in and around facilities containing PCB equipment. Until proven otherwise by laboratory analysis, these must be presumed to be PCBs in these environments and should be cleaned up accordingly. If there is an EPA enforcement action, the institution must establish that these are not PCBs.

Labeling, with the best of intentions, may also lead to misunderstandings. Labels that may be mandated in a given situation by other governmental agencies, are not acceptable in lieu of the EPA mandated labels. Failure to use the correct labeling is a violation of EPA rules. If there is any question, a potential violation can be avoided by simply using all labels that may apply.

Storage procedures for PCB cleanup items must be carefully considered. It is imperative that the staff know the status of each item: Is it clean? Is it contaminated? If contaminated, is it properly labeled and stored? Misunderstandings regarding the status of these items could endanger staff members or, less critically, at least cause problems for the institution. If, for example, clean, dry rags are stored in a designated PCB storage area, they will be inadvertently classed as PCB-contaminated items on the institution's allowable inventories of contaminated materials.

Whatever the reasons for an institution's non-compliance with the EPA rules, the consequences may be quite formidable. By law, fines of as much as $25,000 per violation per day of non-compliance may be assessed; flagrant violators may be imprisoned, and the EPA may initiate cleanup procedures without consent of the violator.

In fact, however, as supporters rather than adversaries, EPA personnel will work closely with institutions attempting, in good faith, to comply with the rules. To avoid the misunderstandings that lead to non-compliance, those in the institution responsible for PCB monitoring and disposal should take advantage of the resources represented by the EPA. Once lines of communication are opened, potential problems can be discussed freely and mutually acceptable solutions implemented.

In a university setting the highest levels of administration must be informed and involved with the problem. This not only leads to better communications in this diverse environment but also facilities the necessary long range planning for the eventual phase out of all PCBs in use.

These plans must include replacement of capital equipment in an orderly manner within the limits set by the final EPA rule; storage and disposal of PCBs and PCB items; and the necessary routine inspections, maintenance, record keeping and management associated with the ownership of PCBs.

The budgetary implications of such a plan for a large multifaceted institution may be staggering and legislative appropriations may well be required for public institutions. However, with forethought the fiscal impact can be spread over many years and, often, incorporated into other capital improvement projects for greater cost effectiveness.

The problems are definitely not insurmountable. Given the attention and support of administrators, staff and faculty, and the cooperation of the EPA, an orderly, fiscally responsible, safe elimination of PCBs from our environment will be accomplished.

Living With Asbestos

By Lt Col John H. Thomson, P.E.
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Introduction

Lurking in the darkness of damp basements and crawl spaces, silently hiding in ceilings and walls, is a politically potential disaster which not only can become a costly venture for the physical plant administrator, but could also totally disrupt the entire campus. This hidden culprit is "Asbestos."

The United States Military Academy is conducting an extensive program in the identification and elimination of the asbestos hazard on the campus. The results of our approach to this issue should prove beneficial to physical plant administrators of colleges and universities whose facilities were constructed prior to the early 1960s.

Information on Asbestos

Before we could address the issue of asbestos at our campus, we took the effort to better understand just exactly what we were dealing with and what approach should be taken to solve problems which surfaced. There is a surprising amount of literature published on asbestos. The first step was to acquire current literature on the subject (Appendix 1). These documents can easily be obtained in sufficient copies to allow all key managers to become familiar with the subject. Next, we programmed the Facilities Engineer, our Environmental Engineer, and our Industrial Hygienist to attend a 3-day seminar on asbestos abatement.

Why Asbestos?

From our research and educational enlightment, we now knew that, because of its insulating and fire-retardant properties, over 60 million tons of asbestos have been combined with binders and used in building materials for years.

Before its prohibition from use in construction materials in the late 1960s, and since the 19th Century, numerous building construction materials contained percentages of asbestos. Such materials as cement products; plaster;

fireproof textiles; vinyl floor tiles; acoustical insulation; thermal and aesthetic coatings on walls and ceilings; plaster or wallboard; insulation and lagging for boilers, steam, and hot water piping are only a few of the areas in which asbestos-laden materials can be found in older buildings.

Asbestos is a natural occurring mineral fiber, mined in many parts of the world. There are six types of asbestos used commercially. These are:

Amosite (Cummingtonite-Granerite Asbestos)
Chrysotile
Crocidolite
Anthophyllite
Thermolite
Actinolite

Amosite and Chrysotile are the most common forms found in building materials. However, structurally, the type of asbestos appears to have no great effect on its potential health hazard. Although 90 percent of all asbestos proructs are safe, old decomposed insulating materials tend to easily crumble and break into small pieces (they become friable). When this happens, small microscopic fibers of asbestos are released into the atmosphere. The same condition occurs when hard asbestos-containing substances such as floor tiles or wallboard are struck, drilled, sawed, sanded, or ground.

The Health Hazard

Environmentally, asbestos fibers are physically and chemically inert and possess no toxic effect to humans or animals. Left undisturbed, either in its natural state or in compounds, nothing happens. Unfortunately, asbestos fibers are durable, fiberous in shape, and unusually small in size (many being less than five microns in length). Under a microscope, they resemble tiny fine splinters of glass. They cannot easily be destroyed or degraded, and their size and shape allow them to remain airborne for long periods of time once disturbed. When we inhale these airborne fibers, the problem begins.

Our lungs are unique in that they can successfully filter out or expel the majority of dust particles which enter the pulmonary system. In the case of asbestos dust, the particles are so small that they enter the lower respiratory track, where it becomes impossible for the body to totally eject all the particles. Because of their sharp nature, they even pierce the cell walls embedding the tissue. There they remain for the life of the host. Repeated dosages increase the concentrations within the lung tissue and, over long periods of time, irritation of the tissue causes scarring and the formation of a disease known as "Asbestosis." This situation reduces the breathing ability of the individual and is similar to emphysema. Although serious, asbestosis is mild compared to the increased potential for contracting both lung cancer and a rare form of cancer called "Pluerl Mesothelioma," which is fatal in 100 percent of the cases diagnosed. No one is sure of why asbestos in the lungs causes cancer. For some reason, after an incubation period of 20 to 40 years, something triggers a change in the body and an onslaught of the disease.

Long-Range Problems

Dr. Irving J. Selikoff of the Mount Saini Medical Center in New York City has done extensive studies in the field of asbestos-related diseases during the last 40 years. He has reached some rather startling findings.

In the early 1900s, doctors began to notice cases of lung cancer and a rare form of cancer known as "Mesothelioma" in workers of asbestos mines in England and South Africa. They began to see a correlation between the mines and the health of the miners. With the invention of the X-ray machine, it became apparent that a significant number of the miners and their immediate families had scarring of the lungs. These studies did not raise any major outcry; and with the boom of the industrial revolution, millions of tons of asbestos products were soon being used in buildings, steam locomotives, and ships. By World War II, thousands of workers in the United States handled and worked with asbestos in our preparation for the war effort.

By the late 1950s and 1960s, these workers began to show an increased incident rate of cancer. Detailed studies were then conducted on such groups as the American Federation of Asbestos Workers (with a membership of over 17,000 employees); the John Manville Corporation; and naval and private shipyard workers. The findings were so significant that asbestos was soon labeled as one of the most dangerous carcinogenics known to man. According to Dr. Selikoff, workers exposed to excessive doses of asbestos dust have one chance in five of dying from lung or other related cancers. Case studies even revealed that brief exposures to concentrations of asbestos dust for only a few months can result in an individual's contracting cancer 20 or 30 years later. For cigarette smokers exposed to asbestos concentration, the chance of lung cancer becomes 50 times greater than for non-smokers.

A pattern had developed where asbestos-related deaths in mine workers had now moved into the ranks of workers who had installed asbestos on piping into walls and used it in construction materials. By 1990, thousands of cases per year of asbestos-related cancer may begin showing up in the United States alone. But, the worst is yet to come. Even though the Environmental Protection Agency and Federal Law banned asbestos products from use in future construction materials, and asbestos companies faced major litigation suits for millions of dollars, what about the material already in buildings? What about the exposure of maintenance workers, custodians, boiler plant operators, electricians, and telephone repairmen who work daily in dusty old crawl spaces, mechanical rooms, and tunnels where asbestos may be slowly crumbling and falling to the floor? And, finally, what about office employees, students, educators, and even homeowners who may be continually exposed to the effects of decomposing asbestos-containing materials in virtually every structure built prior to 1960? No one knows the effect these exposures will have on future generations. Even over the last few years, issues have risen over exposures in public schools; and most leading doctors and scientists agree that the health hazard from asbestos is real and must be a concern to everyone.

Initial Evaluations

Armed with this general knowledge of the potential dangers of asbestos, we then sat down and addressed our approach to the problem at West Point. Before leaping off the diving board, we conducted a review of reference data and gathered our corporate body together to discuss the issues. Included in our discussions were the Preventive Medicine Officer of the Military Academy; the Industrial Hygienist; the USMA Environmental Engineer; the Facilities Engineer; the Chief of the Operations and Maintenance Division; the Chief of the Environmental and Energy Management Division; and contributions from several engineers from the Academic Departments. (If your campus has graduate engineering programs, post graduate students and faculty members, they may be willing to assist in a study of a specific facility or even provide some initial testing of material samples. We were able to save thousands of dollars through the assistance of the Academic Departments.)

Following our initial meetings, a general survey of the campus was conducted. At this time, actual testing of materials was not the issue. Instead, suspected materials and areas were identified for future reference. An inspection sheet for each building (similar to the EPA inspection sheet, Appendix 2) is an excellent tool for this survey. We looked at the obvious areas:

Central Power Plant
Mechanical Rooms
Basements
HVAC Systems
Auditoriums
Gymnasiums
Areas utilizing acoustical tile

Each building was evaluated by age and condition. A careful review of all plans and specifications was conducted to determine the types of building materials. We looked for specifications for materials such as:

Zonolite
Audiolite
Highlite
Sprayolite
Best Wall

used by companies as W.R. Grace, U.S. Gypsum, National Gypsum, Fiberboard, Manville, and GAF.

We also evaluated the degree of risk exposure for materials considering:

Condition of Materials
Water Damage
Exposed Areas
Accessibility
Activity
Air Movement
Friability
Asbestos Content (once known)

We then talked to the maintenance work force and custodians in each building, asking them if they were aware of any areas of flaking material, decomposition, or abnormal dust.

Going Public

With a general idea of the conditions of the campus, we reassembled the corporate body, providing our tentative findings and recommendations. (This is a good time to bring in the President or a local representative of the Union.)

At this meeting, we asked for assistance and suggestions; developed a tentative plan for the correction of any problems; established milestones; and developed a publicity campaign.

Public information cannot be understressed. Like Polychlorinated biphenyl, Ethylene dibromide, and other carcinogens, asbestos is a newsworthy topic and the general public has already been exposed to newspaper articles, publications, and television broadcasts similar to the ABC "Nightline" presentation on asbestos poisoning. Every local newspaper will have articles printed in the last six months on asbestos problems, and such publicity quickly stirs up emotions.

A college campus, more than any other institution, can become the seat of controversy. The best defense is a strong offense. Develop news releases; tell the student body, the faculty, and the administration what will be accomplished; provide information to the work force and the Union; demonstrate that you are concerned and that action is being taken to correct the problems; provide facts and keep information realistic, avoiding emotionalism; ask for help from the student body; be willing to coordinate with the editor of student newspapers and campus publications; consider public hearings; and invite guest speakers to the campus to discuss these issues. One of the greatest mistakes which can be made is to bury one's head in the sand, refusing to face reality. Sufficient documentation exists today to establish (beyond a shadow of a doubt) that asbestos can be a potential hazard. Other owners of buildings have taken action. Your failure to react to this issue could open up the institution for litigation.

Remember, developing a reasonable plan for addressing the asbestos problem, conducting fair information programs, and backing the campus corporate body are the first steps in defusing emotional issues which may develop.

Educating the Work Force

With our general plan in mind and the initial milestones established, the next step was to evaluate the amount of asbestos within each facility and make a determination as to the appropriate action to be taken. We discovered that complete and total elimination of all asbestos-containing materials would be costly, difficult, and most likely impossible. It was like trying to eat an elephant; and we found that one must start slowly and progress steadily. Major abatement should be contracted out to a specialist in the field. Never be so naive to assume that your work force will be able to solve all your asbestos problems. Although minor maintenance, repair, and upkeep can be accomplished by an in-house work force, before initiating any exposure of employees to asbestos, make sure that you fully understand and incorporate all the procedures outlined in EPA and OSHA regulations. Your foremen must be educated in the proper supervision, preparation of site, decontamination of equipment and clothing, wetting procedures, disposal procedures, methods of removal, and encapsulation and enforcement of regulations before you start any asbestos project.

Remember, all employees working in asbestos environments must be briefed on the hazards, how to wear clothing and respirators, and the importance of decontamination to avoid exposure to their families. If you have not conducted detailed classes for your work force on the hazards and handling of asbestos, DO IT NOW! If you have not written a detailed Standing Operating Procedure for asbestos removal, DO IT NOW! If you are not documenting your asbestos repairs, DO IT NOW! If you do not have a medical observation program for employees who are routinely exposed to asbestos, you are behind the times. Remember that plumbers, pipefitters, electricians, and plant operators can all be exposed to asbestos; and liability could be based upon an employer's failure to act in the face of numerous publications indicating that asbestos is a carcinogen which can cause cancer to workers exposed to the fibers.

Going Contract

It soon became apparent that the more our work force handled and worked with asbestos, the more difficult it became to protect them. Therefore, we elected to bring in the experts to get the job done and identify problem areas. There were two approaches:

The first was to hire an architect/engineer firm to conduct a detailed study of the entire campus. We would place the following requirements on the architect/engineer:

1. Inspect all facilities, testing materials in ceilings, walls, duct insulation, pipe insulation, etc., to determine the content and percentage of asbestos.

2. Review plans and specifications to determine hidden sources of asbestos.

3. Identify and locate all friable asbestos materials.

4. Take dust samples from crawl spaces, mechanical rooms, plenum chambers, gym locker rooms, storage rooms, and classrooms to determine the amounts of asbestos.

5. Establish a risk code addressing: Condition of Materials; Water Damage; Exposed Areas; Accessibility; Activity; Air Movement; Friability; and Asbestos Content (once known).

6. Based upon a level of risk, identify:

A. Short-range emergency repairs (i.e., broken and damaged walls and insulation).

B. Medium-range repairs (i.e., removal of ceilings and walls or insulation materials which, although not damaged, will eventually deteriorate, and are located in areas where potential damage could occur).

C. Long-range replacement of all asbestos.

The second approach we considered was to address one or two buildings and develop a contract to conduct an asbestos abatement in only these buildings. The criteria would be similar to the general study listed above.

We elected to go with the first choice, of doing the entire campus. (Be prepared to spend money to accomplish the initial architect/engineer survey. For an entire campus of several million square feet, you will be paying more than $100,000 just for the survey.)

Once we had the results of the survey, we then selected a competent contractor to begin the abatement projects. Our approach was to tackle the worst area first. Like all contracts, asbestos abatement projects are only as good as the specifications. Remember, you cannot expect anything from a contractor unless it is placed in writing or you plan to spend more money modifying or changing the contract.

An asbestos abatement project must also address:

1. Detailed on-site monitoring to ensure that construction adheres to current regulations for the removal of asbestos materials.

2. Inspectors being fully knowledgeable of the rules and regulations of the asbestos abatement.

3. The definition of testing criteria, acceptance, and performance standards.

4. Coordination of fire plans as a result of barriers used in abatement programs.

5. Requirements of contractor to post area and protect perimeter of project. (This is particularly true in demolition-type projects.)

6. Fully bonding and insuring of contractor.

7. Contractor's credentials, insuring that he meets State and Federal requirements for certification and training in the removal of asbestos.

8. That the specifications must be achievable, clearly spelling out how the asbestos is removed, protective equipment, enclosures, etc.

By now, we were aware that asbestos abatement was no simple task. We had looked at the requirements for protecting and educating the work force, the methods and source of testings, contractor requirements and, of course, the legal and health aspects of contamination. We realized that a contractor conducting a proper removal program would have a work site which surpassed the sanitation efforts of the space program.

Even negative pressure-plasticized chambers may need to be constructed; a decontamination trailer might need to be brought to the work site; and workers would be required to work under the harshest conditions, wearing throw-away coveralls, respirators, and working in temperatures which exceed 100°F. Employees cannot even wear outside clothing under the coveralls since contamination could result in bringing asbestos fibers into their houses. Following the project, cleanliness of the work site was equal to that of an operating room. For these reasons, we found that the cost of removal could vary from $3.50 to $10.00 per square foot, depending upon the area of the country and the conditions.

Will It Go Away?

With the costs and the complexity of asbestos abatement, your first thought might be -- "Why not forget about the whole issue?" Unfortunately, the scientific data and statistics to date indicated that asbestos contamination could become one of the greatest health hazards of the century. Obviously, as a result of the high dosage rates of maintenance workers and individuals in the manufacture of asbestos, they now have significantly greater chances of contracting cancer. But even minor exposures in classroom environments, basements, and auditoriums could (in the long range) result in significantly greater risks of cancer. For example, the University of Pennsylvania Veterinary School made a startling discovery in the late 1970s. Eighteen cases of mesothelioma showed up in dogs which was, heretofore, unknown in animals. A study of the 18 cases revealed that the dogs were pets of men who had worked in asbestos-related jobs. Apparently the asbestos brought home on the workers' clothes resulted in the dogs contracting the disease. As time goes by, more data continues to reveal the seriousness of asbestos contamination.

For this reason, failure to retain records and documentation of corrections of deficiencies in buildings at your university could expose the institution to litigation. The physical plant administrator could even be found criminally negligent for failure to correct hazardous asbestos conditions within his facility. Therefore, some action must be taken, and a sound program must be established.

Conclusion

Our job at West Point has just started. Asbestos will be with us for years to come and we now face such difficult decisions as whether to encapsulate or remove future asbestos products. Even this decision is not simple and must be evaluated in terms of both short and long-range costs.

Although, on first thought, encapsulation appeared to be the most cost-effective and reduced the release to acceptable levels, remember that the minimum standard could be changed. You would still have the asbestos; some sealants cause damage or are aesthetically unsuitable; you must continue to maintain and inspect; and the encapsulated asbestos may be more difficult to remove.

For these reasons, the physical plant administrator must be knowledgeable of asbestos pollution; insure that the work force can safely maintain asbestos materials; and develop a plan to analyze, inspect, and eventually remove potentially hazardous asbestos areas. Admit you have the problem, take steps to correct it, document your efforts, and we can all live with asbestos.

Appendix 1

PUBLICATIONS ON ASBESTOS

Asbestos-Containing Materials in School Buildings -- A Guidance Document, Parts One and Two. Published by the United States Environmental Protection Agency (USEPA), Office of Toxic Substances, Washington, DC 20460, March 1979.

Asbestos Exposure Assessment in Buildings. Inspection Manual published by USEPA, Region 7, 324 East Eleventh Street, Kansas City, MO 64106, October 1982.

Guidance for Controlling Friable Asbestos-Containing Materials in Buildings. Published by USEPA, Office of Toxic Substances, Washington, DC 20460. EPA 560/5-83-00E, March 1983.

Policy and Guidelines for Asbestos Management. Department of the Army Circular 40-83-4, HQ, Department of the Army, Washington, DC, 15 December 1983.

Friable Asbestos-Containing Materials in Schools, Identification and Notification. Federal Register, Part IV, EPA, May 27, 1983.

The Attorney General's Asbestos Liability Report to Congress. U.S. Department of Justice, Land and Natural Resources Division, Washington, DC 20530, September 21, 1981.

Appendix 2 -- **Example Building Inspection Form**

BUILDINGS EVALUATION FORM #2
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VII - TOXICS AND PESTICIDES SECTION
324 EAST 11TH STREET
KANSAS CITY, MISSOURI 64106

Date:_______
Dist. No.:_______

Room:______________________________ Sample Number(s):__________________

Building:________________________ Address:______________________________

Evaluator:_________________________ Phone No.:____________________

Coated Area: Ceiling Wall(s) Structural Members Above Suspended Ceiling
Pipe Lagging Boiler Insul. Other:__________________

Type of Ceiling: Concrete 3 Coat Plaster System Suspended Metal Lath
Concrete Joists and Beams Tile Suspended Lay-In Panels
Metal Deck Corrugated Steel Steel Beam or Bar Joists

Ceiling Height:_______________ft.

Ceiling Shape: Flat

Dome

Other (draw):

Folded Plate

Barrel

Type of Wall (If Coated): Smooth Concrete Rough Concrete Masonry
Plasterboard Other:______________________

Amount of Friable Material in Area being Evaluated:__________________sq. ft.

Description of Coating: Fibrous (highly friable) Granular/Cementitious (soft) Concrete Like (hard)

Thickness:_________inch(s) Is thickness uniform: Yes No

Coating debris on Floor/Furniture/Work Surfaces: Yes No

Curtains, expandable partitions, etc. being pulled across coating: Yes No

Type of Lighting: Surface Mounted Suspended Recessed

No. of Lights:__________ Type of Heating/Cooling Systems:______________

Type of Floor: Concrete Tile Wood Carpet Other:____________

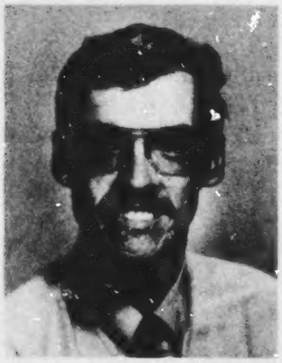
What is above the room being evaluated?______________________________

____

Comments:____

____

____



Grounds Maintenance Contracting Versus In-house Labor

By Larry G. Steward
University of Virginia

The University of Virginia Physical Plant has been contracting different phases of grounds maintenance for over twenty years. Much of it was entered into without preparation or planning, but being required to do so or stop servicing the University community. In almost every case, the University of Virginia started contracting due to either lack of money for very sophisticated or expensive equipment or because of a labor hiring freeze.

Contracts are in nine different areas of grounds maintenance. Some, such as trash removal, may or may not be part of your grounds program. The nine areas that are listed as follows by length of experience in contracting are: (1) trash removal - the dumpster type of trash removal; (2) tree maintenance; (3) tree or large plant moving; (4) spraying exterior (interior pest control contract is handled under building maintenance, not grounds maintenance); (5) grass cutting; (6) snow removal; (7) pavement repair and paving; (8) street sweeping; and (9) landscaping of major projects, such as new buildings, new areas, or large renovation projects.

The oldest area that is contracted, yet newest to the grounds maintenance landscape division responsibility, is trash removal. This was just transferred to this division about one year ago, but trash removal has been contracted for over twenty years at the University of Virginia. This department used to do all pick up of bulk trash, but it became very inefficient and hard to maintain very expensive equipment with no funding for replacement. Twenty years ago this University was approximately five thousand students; now it is well over sixteen thousand and along with this equal number of staff and faculty members. It was soon demonstrated that with this group of people, a need for large containers to collect the trash was necessary which evolved into the dumpster type pick up. From two surplus twenty-yard compactors of its own, the University now has furnished by contract two large compactor trucks, one roll-off truck, and over two hundred and fifty dumpster containers and compactors, and a contract that amounts to over a quarter million dollars per year. It has worked out very well; however, there are problems other than just expenses - namely keeping the contractor maintaining his equipment in first-rate condition and clean.

The next general area of contracts is tree maintenance. The University has over ten thousand trees in the intensely landscaped grounds, plus many more in outlying wooded areas. The first group of trees are on a planned and scheduled maintenance program while work in the other areas are on an "as-needed" basis only. Tree maintenance contracting has been done for thirteen years. The reasons for starting this program was due to the fact that the State was not competing with the outside companies with pay levels for a tree climber. In the early 1970's the State tree climber rate was about two-thirds to one-half the outside rates. It also was only paying nine cents more an hour than the groundsman who was not taking any of the chances or risks in climbing the trees. Many of our trees are up to one hundred feet in height, requiring expertise not found in inexperienced climbers. This department would end up with many of the people that were laid off by the outside contractors or they would come to work in the wintertime and would only show up for work on days that were raining and snowing. Many of these individuals did tree work on the side to make ends meet and they would take off from work on clear days. So consequently, the University did not get much time of actual tree maintenance, tree pruning, or tree work. As soon as warm weather came in the spring, these climbers either would go to work for themselves or go back to work for the tree companies in the area. The trees were deteriorating into very dangerous, unhealthy plants.

This department also was not funded for the expensive equipment such as chippers, bucket trucks, and stump grinders. Anytime this type of equipment was required, contractors were called in anyway. So it was felt that for these reasons along with the liability of an inexperienced crew dropping a tree across a car, it proved best just to get more experienced, more professional people.

Two contractors are used - one as a backup to the other. They all have their own private business scheduled, so having two permits the University is able, in case of an emergency, to call and bring at least one crew onto the grounds. Both contractors are highly competent and are nationally known companies. They have been very helpful in updating tree maintenance programs as far as budget constraints allow. The contracts that have developed over the years are quite tight and are reviewed annually. A very high insurance coverage is required which most of them tell me is not that expensive; both contractors have coverage of well over two to three million dollars. The contracts have tended to eliminate so called "pick up" operators and off-duty line clearing butchers from getting "low bid" work on the grounds. These people have to be quite experienced in high tree climbing, actually climbing with a hydraulic-powered saw and "butchering" the trees. We require our contractors to be working according to the National Arborist Association standards and, of course, all Occupational Safety and Health Administration (OSHA) standards.

There has been some problems with, shall we say, misinterpretation of the University's requirements of the contract, but through negotiation and discussion with the contractors these have been settled usually without problems.

The next area of contracting for discussion is tree moving. This has been in existence for about nine years. There is a local contractor that has had several Vermeer tree spades. These are the large four- and six-blade spades mounted on the back of either two- or four-wheel drive trucks. The first instance of one was needed in the University's Lawn. There were two trees planted, in what was felt by a donor to the University, to be out of place. The University has an arboretum committee made up of faculty and staff which oversees the planting, removal, and maintenance of trees. In this mentioned instance, this particular donor wanted these two trees moved from the Lawn and influenced the administration to get them removed. I received the call one evening and was asked to have these two particular trees removed prior to school starting the next week and as quietly as possible. Well as you know moving trees by hand (these were about three-inch caliper trees, and fifteen to twenty feet in height), and "spiriting" trees out of an area is rather hard to do. A friend of mine suggested that there was a new person in town with a tree spade on a one and one-half ton truck that would move these two trees very quickly. I contacted the person, we brought him in, he moved the two trees in one evening's time, and plugged two grass plugs back in the holes, and by the next morning there were no trees in this particular area of the Lawn. I will leave the story there.

It was not too many months after this incident that a local nurseryman presented the University of Virginia with a nursery with about twenty-five to thirty acres, not the land, just the plants on the land, and a lot of this was older, mature stock well beyond the size to dig by hand. This department had until June 30th to get them out of the nursery and moved onto the University grounds. Notification of this came during one the coldest January's on history in Virginia. In fact the soil was frozen eighteen inches deep at this time. Now this is very unusual for Virginia. The contractor was finally able to start on February 15. He then got a larger Vermeer spade (sixty-six inch), and a smaller spade (thirty-three inch), plus his forty-four inch spade and started moving plants. The University landscape architect had to quickly develop plans for locations. Between the middle of February and midnight on June 30th, the tree contractor moved day, night, and on weekends eight hundred and twenty-five trees and large shrubs. There has been to date, about a ninety-five percent survivability on these plants. The largest tree moved was a twelve-inch caliper Sweetgum, that looks beautiful even today. Even the nurseryman and the people of the community were very much surprised in the ability that was demonstrated in moving that many plants in that short period of time; even with rain in late spring making it too wet to get into the nursery. All this work was accomplished without any loss of time by this department's staff from doing their regular maintenance duties during the most demanding time of the year. Further, this contract has presented us with great versatility and the ability to accept large plant gifts at minimal costs.

Another type of contracting done is spraying. Nine years ago this was part of the tree maintenance contract and then our tree maintenance program became too big for the contractor to handle, along with the spraying requirements and the spraying tended to slip. It was then established as a separate contract. With the environmental issues that arose in the early 1970's, there was less criticism received by going with a contracting company with the big sprayers and a professional appearance. Now with certification and the extensive bonding required and insurance, it is much more economical to go with a contractor who carries the large liability coverage. I am a State certified applicator and specify according to Virginia state recommendations as to spray material to be used. Another advantage is the fact that the contractor can come in and spray at odd hours; such as at dawn or early evenings. This is especially important at this time of year, for instance as this past week temperatures have been in the mid 90's. Further, these spraying hours do not disturb the students and faculty as they are not aware of the spraying operations being completed.

A rather recent contracting area which is now in its third year is mowing. A hiring freeze was imposed plus no financing for replacement equipment making it necessary to contract in order to mow the total eight hundred acres of the University. This department went from a normal mid-summer mowing staff alone of twenty-four to thirty people, to ten people that work fulltime. So needless to say, it was just not possible to maintain the area properly. An area of about one hundred and twenty-five acres was contracted the first year. At that time the cost to contract was equal to the cost of hiring people; however, this department did not have to pay benefits for non-work days or for replacement equipment. Also overtime for weekends did not have to be covered. The contractor was paid a base price for mowing the area and had a deadline to meet of within ten days to two weeks. So if it rained, he had to complete it even if he had to mow it in the evenings, after dark, or on weekends. It did improve also the routine maintenance of grass cutting, because with the shortage of in-house help, the little extras like trimming and edging out areas in some of the outlying grounds was not done. Further the summer help was never available until late in May, which was after all the preparation for graduation had been accomplished. Many outlying areas did not get mowed for the first time in the spring until early June. Also when school started in August, the summer help left, leaving this department to mow the fall growing season with a small winter, fulltime staff. The other advantage to contract mowing is it releases the limited University personnel to doing special requests and taking care of the more intensive type of landscaping required in the historical grounds area. However, with the increases due to inflation and built-in increases to the contracts, study is being done to see if costs are still equal and proportional. The other disadvantages are more subtle to the fact that reports of other problems in these areas are not turned into this office, which when was done this department's crews did the work; for example tree branches down, shrubbery problems, or spraying needs.

Another problem arises when an area is "trashed" by the students. The operators of the mowers tend to "kick" the trash out or the way and keep on mowing, even though the contractor is required to pick up the trash. This then means finding the contractor or his supervisory person, stressing the importance of appearance of the grounds, and getting the trash removed.

As with all contracts, one needs to write very tight specifications. All terms need to be defined exactly and be sure that there is no conflict of terms. This department right now is re-negotiating the mowing contract because of some confusing wording in the original contract. I am sure that it will be satisfied and worked out, but it has caused quite a few hassles and turmoil in trying to get the grass cut prior to graduation.

The paving and pavement repair contracting services came about when it seemed that this department just did not have the equipment or expertise to repair paved surfaces properly. Also parking lots would be broken up extensively during the winter and this exceeded the "in-house" abilities to complete the needed work.

Contracting on an annual basis permits easier budgeting for replacement of parking surfaces as prices are known for at least twelve months. This was very important when oil prices were jumping as they were a few years ago.

The present contractor is also a paving contractor for the State Highway system in the Charlottesville area and the supplier of blacktop asphalt to all other distributors. This does permit a lower contract price as the "middle man's" profit is cut out.

Two more recent areas of contracting that this department has obtained is snow removal and street sweeping. The first is done on an area-accomplished basis as the mowing contract is done. The street sweeping is done on a per-hour basis. The snow removal was added to make the University's total snow removal program more efficient and quicker. One must have a set snow removal schedule prior to contracting as it is necessary to have a priority set up on parking lot clearances and a place for the people to go while their assigned lot is being cleared.

It is also very necessary for the contractor and his operators to see the areas to be cleared prior to the first snow. If this is not done it will be disastrous to curbs, bumper blocks, trees, and other obstructions.

The sweeping contract is new to the University, as in the past this department's crews have done this with a small parking garage sweeper, manually, and with the rain. The city street sweepers have also been used during their overtime and at their overtime rates. Their overtime hours were afternoons when the University's parking areas were full of cars. Consequently, little or no clean-up was accomplished.

The present contractor sweeps during the night hours or during the days depending on when I determine will be the most efficient use of the machine. Further, there is no difference in price per hour for this variability of schedule.

The last item that has been contracted out for many years is landscaping of new buildings. Again, this has come about just from not having enough manpower to do both maintenance and new construction. Another reason landscaping is contracted out is that this department did not have space for nursery stock to be kept in storage, grow it, or the manpower to maintain it. It was much easier to go out and purchase plant material outside. This department still holds the right to inspect and approve all plant material prior to its coming to the University even from outside contractors. Also the landscaper must maintain the plant material for the warranty period of one year. This way there is no argument as to whether or not it has been maintained. If he did not maintain it, he still has to replace it. If he maintained it and it comes well, he does not have to replace it.

Actual expenses in some work areas would be much more costly for the University to do ourselves, due to the specialized equipment involved; for instance: tree moving, tree maintenance, spraying, paving, and sweeping. By contracting the routine items, such as mowing, it permitted this department's people to become more highly trained and work more extensively and intensively in the University's high-maintenance areas. Further, since the grounds crew does only outside work, this department is not required then to carry a huge number of people over the wintertime when they are not necessary. This department's wintertime schedules are primary snow removal, leaf cleanup, mulching, and some fertilizing. While specific costs appear higher during the summer due to contracting, the overall department's yearly cost does balance out.

The only comparison I have of actual costs of outside contracting versus in-house labor is included on the attached chart. For the last four years, the first year of departmental mowing is compared to the last two years of contract and an intermediate year of contract and departmental mowing. As you can see, it has been a steady increase in charges for mowing; the contract mowing is proportional to the increases of cost to in-house mowing expenses though. However, the reduction of full time staff and the reduction of equipment purchased has permitted the overall budget for grounds maintenance to level out to meet the state's guidelines.

In conclusion, I feel that if you are planning to go into a contract basis for grounds maintenance, you need to talk to people in your area who are already involved in it, both contractors as well as the people who are contracting the services. Be sure that contracts are clear, complete, and easy enough for anyone to understand. Be sure that at least one pre-bid conference is scheduled so that any questions can be answered. Further, with all the best preparations made, be prepared for any type of hassle, blow-up, litigation, or anything after the contract is let. No matter how smooth the contracts are going, there is going to come a time that one word may be out of context or misinterpreted. Then there is going to be a contract dispute or litigation.

When this department started, no one was contracting any services for grounds maintenance in this geographical area and so specifications started from a very short set and have developed now into small books. Further, the more extensive these specifications become, the more important it is to review them to be sure they say exactly what you want.

Contracting of services definitely requires generally a much tighter supervision of personnel, more pre-planning of work, scheduling to be sure all work is accomplished in a timely and cost-efficient manner, and reams of paperwork. So be prepared for it prior to starting this method of completing your grounds maintenance.

Should you have any questions or wish copies of our contracts, I will be glad to answer your requests. Thank you very much.

COMPARISON OF MOWING COSTS

OWING AREAS	1980-81	1981-82	1982-83	1983-84
entral Historical Grounds	* $ 61,196	* $ 60,966	* $ 81,561	* $ 90,041
ospital Grounds	* $ 9,067	* $ 11,496	* $ 14,443	* $ 14,503
est Grounds	* $ 51,270	* $ 71,398	*+ $ 65,486	+ $ 98,570
orth Grounds	* $ 38,870	*+ $ 36,284	+ $ 64,692	+ $ 76,550
	$160,403	$180,144	$226,182	$279,664

= University Staff

= Contractor Staff

+ = one half of fiscal year done by each staff.

METHOD FOR INVESTIGATING FEASIBILITY FOR CONTRACTING PHYSICAL PLANT SERVICES

By Howard A. Wells, Jr.
Director of Physical Plant
Oregon State University
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Many times the very mention of the subject "Contracting for Physical Plant Services" strikes fear, emotion, and unrest in the hearts of managers as well as workers alike, so any serious consideration of contracting out Physical Plant services should be approached with great care and a full understanding of the actions and consequences that follow. The purpose of this presentation is to try to provide a general way to investigate whether or not the contracting for Physical Plant services has the potential of providing a significant savings for your institution. This method has been formalized through my experience in having gone through this process in the State of Oregon where the recent recession has caused very serious funding shortages at the State Institutions. In the Oregon System, there are now three that are serviced by contract custodial firms, and there are five that remain to accomplish the function in-house. The details of those contracts are really unimportant in this discussion, but what is important is that the change to contract services provided very significant savings for those institutions at a time when funding shortages were threatening academic program cuts.

In the fall of 1982, Portland State University had acquired a contract for custodial services and significant savings were apparent. With that information, the Administration at two other institutions, one of them Oregon State University, directed that we should proceed to prepare plans and specifications for soliciting bids to determine if there would be significant savings by contracting for custodial services. We did so, benefiting from the hardships that Portland State University had endured by obtaining a too low priced contractor and we proceeded with specifications to ensure we would maintain the same quality custodial service that we had been providing and to ensure that we would be able to control that quality through contractual requirements throughout the life of the contract.

Of course one method of finding whether significant savings will result is to proceed all the way through the bid process, but there should be an adequate way to generally determine the feasibility long before that threshold is reached. The following part of this presentation is intended to deal with that general method and not to deal with any specific contract details at Oregon State University. Prior to our bid specifications, the Labor Management Agreement in effect provided for the ability of the institution to contract out functions quite freely; however, as a result of these actions most recent negotiations have resulted in wording that more nearly reflects that there must be a feasibility study. The exact wordings of the old and the new are as follows.

> Article 13 - Contracting Out 1981-1983
>
> Should any regular full-time employee who is a bargaining unit member of OPEU become displaced as a direct result of the contracting out of work previously done by bargaining unit members, the Employer and the Union shall meet to discuss the effect of such contracting out on bargaining unit members. The Employer agrees to make every good faith effort to place those employees elsewhere within the bargaining unit in the same classification and at the same rate of pay, without loss of pay during the period of readjustment. This Article shall not, however, apply to employees who hold seasonal, unskilled positions.
>
> Article 13 - Contracting Out 1983-1985
>
> Section 1. The Union recognizes that the Employer has the management right, during the term of this Agreement, to decide to contract out work performed by bargaining unit members. Such decisions shall, however, be made only after the affected agency has conducted a formal feasibility study determining the potential costs and other benefits which would result from contracting out the work in question. The Employer agrees to notify the Union within one week of its decision to conduct a formal feasibility study, indicating the job classifications and work areas affected. The Employer shall provide the Union with no less than thirty (30) days notice that it intends to issue bids to contract out bargaining unit work where the decision would result in displacement of bargaining unit members. During this thirty (30) day period, the Employer shall not release any bids and the Union shall have the opportunity to submit an alternate proposal. The notification by the Employer to the Union of the results of the feasibility study will include all pertinent information upon which the Employer based its decision to contract out the work including but not limited to the total cost savings the Employer anticipates.
>
> Nothing in this article shall prevent the Employer from continually analyzing its operation for the purpose of identifying cost-saving opportunities.
>
> Section 2. If the Union's proposal would result in providing quality and savings equal to or greater than that identified in the management plan, the parties will agree in writing to implement the Union proposal.

> Section 3. Should any full-time bargaining unit member become displaced as a result of contracting out, the Employer and the Union shall meet to discuss the effect on bargaining unit members. The Employer's obligation to discuss the effect of such contracting does not obligate it to secure the agreement of the Union or to exhaust the dispute resolution procedure of ORS 243.712, 243.722 or 243.742, concerning the decision or the impact.
>
> Section 4. Once an agency makes a decision to contract out, it will either:
>
> (a) Require the contractor to hire employees displaced by the contract at the same rate of pay for a minimum of six (6) months subject only to "just cause" terminations. In this instance, the State will continue to provide the employees with six (6) months of health and dental insurance coverage through the Bargaining Unit Benefits Board; or
>
> (b) Place employees displaced by a contract elsewhere in state government in the following order of priority: within the agency, within the department or within state service generally. Salaries of employees placed in lower classifications will be red-circled. To the extent this article conflicts with Article 45 - Filling of Vacancies, this article shall prevail.

This type of wording in a labor management agreement should not pose a problem for any institution for it is highly recommended that such a feasibility study be completely conducted before you embark on such a task as contracting out for Physical Plant services.

As I indicated I don't want to deal with the specific details of the specifications other than to point out there are several areas in which the specifications must be precise to provide you the adequate administrative control over your future destiny of acquiring a service by contract:

1. It's very important to ensure that you gain the services of a contractor that is experienced in the wide range of facilities and size of facilities that are present at your institution.

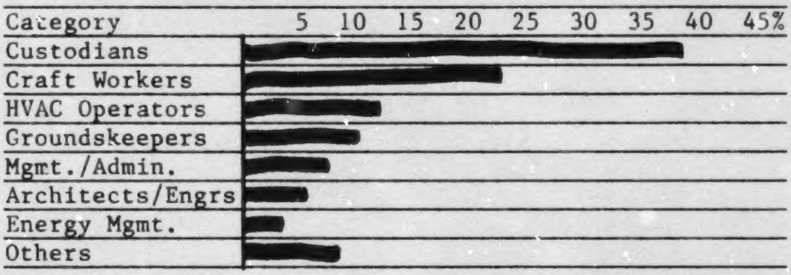
2. The reference checks are very important to ensure that, in fact, the organization has been able to perform in similar situations.

3. The inclusion of a concept for clearly stating, in advance, what you believe is the absolute minimum worker hour plan required to accomplish the task, not withstanding the fact that this smacks of trying to tell the contractor how to do his job. Failure to do so usually leads to an excessively low bid and a fight for the life of the contract.

Most importantly, I'd like to provide a little insight for determining which Physical Plant service function may have potential for providing significant savings to the institutions. If we look at the broad spectrum of services we provide, custodial is certainly one with a large number of people and is the candidate for analysis. The following division of Physical Plant employees is taken from a WACUBO Facilities Management Survey dated May 1, 1984, and the results of the survey conducted on Western Region universities for presentation at the WACUBO conference in Hawaii in May 1984.

Custodians Make Up the Largest Number of Physical Plant Employees

Craft Workers account for only one out of four employees, Groundskeepers one out of ten. Thirty-eight percent of employees are Custodians. Management and Administrative employees account for only six percent of the total, which is below the level normally found in business organizations.



The entire maintenance force itself, of course, is one which can be accomplished by contract. Examples most recently within the Department of Defense for the new Trident Base in the State of Washington started from the onset with a plan to accomplish the entire base maintenance and operation function through contractor provided services. When you compare the method of accomplishing a given service in-house with that of doing it by contract, if I may use the term "out-house", there are a variety of factors that these functions are composed of. The following comparative matrix lists the components of any given function as I see them; however, there may be others that you might consider important enough to use as a special area of analysis that I have not included.

In comparing in-house service among the variety of services that we perform in Physical Plant, we'll find that all our in-house employees generally have the same benefit package, operate under the same procurement rules, generally under the same management of our directorships and so forth. When we compare that type of service with the service most generally available in the commercial area outside our campus, we may quickly find that the fringe benefit package that "society" provides for a custodian in the commercial arena is quite different from that provided by us through our institutions. To begin with, I'll utilize this matrix to show a general comparison as we saw it in our Oregon environment as we started analyzing whether there is a significant opportunity to realize savings in the custodial area.

CUSTODIAL	IN-HOUSE	OUT-HOUSE
Base Pay	--	--
Other Personal Expenses	↑	
Materials Supplies	--	--
Equipment	--	--
Profit		↑
Quality	--	--
Productivity	↑	
Other Labor Mgmt. Relations	↑	

As we analyzed "Base Pay" for state workers in the custodial area with that which the Portland State experience produced through a union contractor, it was realized that in the base pay area, there is not an enormous difference, and I'll generally show that on the matrix as a dash line to recognize a push. In the "Other Personnel Expenses" category, we found an enormous difference between the fringe benefits paid to state employees and those paid to a contract employee even with union benefits. In this case, I'm going to draw a very large arrow in the in-house column pointing up to show that there is a significant factor dealing with cost that is not in favor of in-house continuation. In dealing with "Materials and Supplies", I found this area to be a push. The same goes with "Equipment". In dealing with the factor of "Profit", by design, in-house we operate towards a zero profit situation and the contractor works for profit. I have shown a small arrow in the out-house column to show that a contractor has a profit factor but that the custodial market operates probably on a small margin of profit. In the category of "Quality", I've shown as a push because we designed our specifications to provide the same quality. In the category of "Productivity", I will show a small arrow upward in the in-house area indicating I believe that a contractor can create a more productive situation than we can by bringing a stronger overall intensive management program to bear on the function. Again here, it's a small arrow. In our case, I believe that we had a well managed work force but that the contractor could do a little bit better. In the category of "Other Labor/Management Relations", I'm alluding to the presence or the lack of an in-house union and/or association that governs the relationships by which managers have to deal with their employees. In our case, I show a medium sized arrow which is my expression of belief that the contract between the Executive Department of the State of Oregon and the Oregon Public Employees Union is a factor that makes it more difficult for us to control productivity and overall service than does exist in our environments for the commercial contractor.

In reviewing this general analysis, the "Profit" arrow of the contractor is generally offset by "Productivity" and certainly by "Other Labor/Management Relations." These are two areas which we could improve somewhat with significant management action; however, the one overwhelming factor of this analysis is that large arrow in "Other Personnel Expense." In our case, the analysis for the custodial function, an area which is very labor intensive, we found that for every hour paid there was about a $2.50 per hour cost in the fringe benefit area as compared to about a $1.00 per hour cost in the out-house contractor mode. In my judgement, this was a factor that was beyond any control that I could exercise as a manager, and from this general analysis it seemed that there was a real significant opportunity for real savings by going out to bid.

When we did go out to bid, we were able to analyze the bids carefully in conjunction with the General Services Department; and through the provisions we included in the bid documents, we finally awarded the contract to the fourth low bidder, but the one who was the low qualified bidder. Even by going to the fourth low bidder, we ended up with a two year contract with an average across the board savings of 24%. Enclosure (1) is a detailed analysis of the major items of base pay and other personnel expenses that we used in comparison in the early stage of our analysis.

The case presented is the one in which we analyzed for custodial, but other Physical Plant services can be analyzed in a similar fashion. If we take the same matrix above and use it to generally analyze the function of maintenance services, we will find that the analysis comes out quite different.

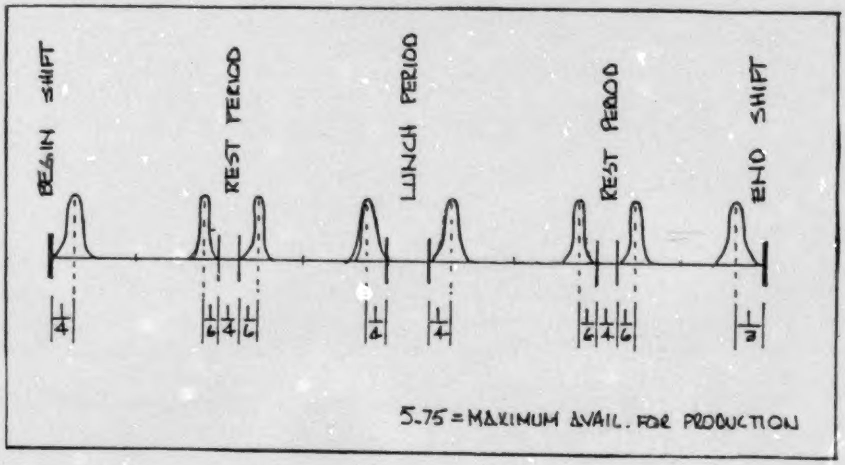
CONSTRUCTION TRADE - Carpenter	IN-HOUSE	OUT-HOUSE
Base Pay		↑
Other Personal Expenses	--	--
Materials Supplies	--	--
Equipment	--	--
Profit		↑
Quality	--	--
Productivity	↑	
Other Labor Mgmt. Relations	↑	

In the "Base Pay" arena we find that in the construction trades, (carpenter trades specifically) the out-house cost is significantly higher than in-house and, I have used a medium sized arrow in the out-house column. In the "Other Personnel Expense" area, the contract packages fringe benefits for construction workers in our area more nearly matches that which state workers receive, so I've shown two dash lines that show that there is not a significant difference here. "Materials and Supplies and Equipment" are areas that generally come out about the same in either case, and again dash lines are shown to indicate no significant differences. In the "Profit" area, again zero profit in-house is the goal, and a slightly larger arrow than in the custodial is shown, since profit margin in construction is usually higher than in the custodial area. "Quality" is a push as long as you accomplish appropriate inspection.

In the area of "Productivity", I believe that the contractor is generally more efficient in gaining higher productivity for the hours of work performed, and therefore, I show a medium sized arrow in "Productivity" for the in-house accomplishment. In "Other Labor/Management Relations", it's my analysis that our labor/management contract is a bit more restrictive than that in which the construction trades exist in the commercial environment. In a general review of this, you can see that it is quite different from the custodial situation. You might assume that in-house "Productivity" and "Other Labor/Management Relations" reasonably offset the "Profit" situation. Since there is something that I could do within my authority as a manager, I can probably change that productivity arrow and make it much smaller or make it disappear in which case in-house accomplishment would remain far more cost effective. Enclosure (2) contains a more detailed comparison of the actual costs we see in our area. At any rate, this kind of general analysis is quite important to start your feasibility study. If there does not seem to be a general opportunity for gain, then it's difficult to go through the whole process, and I guarantee you it's painful to go all the way to bid on contracting out your work force if you don't have a high likelihood that you're going to find a significant savings.

In analyzing the subject of "Productivity" and "Other Labor/Management Relations", I would like to show an example of things that I have observed over the years that are areas that probably can receive increased input by a more enlightened management group with the purpose of getting the worker involved in understanding how his actions influence the overall productivity, the overall cost of the work we do, and in the long run, may very well determine whether or not he or she continues to perform the job as a University employee.

In the figure below, I have shown what I have found to be a truth that occurs in situations involving a shop work force that has the responsibility for maintaining a campus or similarly a military base.



My observations come from a variety of years at different places watching shop environments. As I go through this you may very well see that this resembles what happens at your institution as well. The time line I have shown is intended to represent the start of work day on the left and the end of work day on the right. In the middle, the break represents the lunch period which varies from institution to institution. Mid-point between the start of work and lunch period, and also between the lunch period and the end of work, is a rest period or break period. In our case, this rest period is written into the labor contract as a 15 minute rest period. For those of you who do not have such things formally etched on labor contracts or who are now working up labor contracts, I would highly encourage that you argue the point that a formal rest period is unnecessary in that the modern day work situation provides a sufficient opportunity for the required rest as we go through the day. I think you'll see why I make that pitch very shortly. Those rest periods are a quarter hour each. The balance of the chart above the time line, which appears to be the Saw Tooth Mountain range in Idaho, is really a series of normal distribution curves not precisely calculated, but generally drawn to approximate what really happens in the way of personnel reporting to the shop and ultimately getting out and being productive on the job. My observations over a period of fifteen years show that there is an average or median of about a quarter of an hour between the time of start of work and the time that people actually commence productive work. At the end of the work day, that quarter hour is probably twenty minutes by the time you take into account the general desire of people to get home, and the fact that you may have a minimum amount of time for cleanup. My observations are that workers return to the shops for lunch and without significant control, they will be at the shop at the time of the lunch period start, and they won't leave until it's over generating at least fifteen minutes of travel time, non-productive, before and after the lunch period. By the time you introduce two rest periods, if they are not highly controlled, you have just now added four more periods of one-sixth of an hour each. Again, these are based on my observations.

Your analysis may agree or disagree, but these occurrences in one shape or form do exist. Quickly adding these up results in an average in the shops of 2.25 hours that the employee is being paid for, but is not producing. Subtracted from an eight hour day gives you 5.75 hours work maximum for eight hours pay. Roughly comparing this with the contractor situation, there will be rest periods but in most cases a contractor would expect his people to report to the job site, start work at the start of work, and not have a to-and-from shop travel situation involved. Some things that can possibly be improved in this analysis certainly are that rest periods taken at the shop need not be a guaranteed right, and there may be some ability to change through management directives or through labor/ management cooperative endeavors to make the workers fully realize the impact of this type of behavior upon the productivity of our work force. The purpose in going through this analysis is to show that there may very well be some areas in "Productivity" and "Other Labor/Management Relations" where significant management attention can bring changes such that contracting-out will not produce a significant savings.

What is a significant savings? For those of you who are familiar with the Office of Management Budget Memo A-21 in the federal sector, one of the guidelines included in that document for contracting out, is that unless there is a 10% savings, there should not be a change from an in-house accomplishment to an out-house accomplishment. The fact that we're dealing with employees who have been our friends, fellow-workers, and members of the university community for a long time is certainly one reason for getting something over 10% savings before you consider it significant. Having just gone through the process, I guarantee you that a three inch thick notebook full of all the paper clippings and the articles, the "Oh my God, ain't it awfuls" and everything else over the past several years is an experience that I don't wish on any of you, but it is something that you fully need to realize before you start this process.

Hopefully, some of the above items that I have provided can assist you in approaching the feasibility study portion of the process to find out if there is fertile ground that will produce a very significant savings by changing your method of accomplishing Physical Plant services.

Custodial Services: Comparison of In-House vs. Contract Services

	Agreement Between OPEU and State of Oregon IN-HOUSE		Agreement Between SEIU and Jan. Contr. Assoc. CONTRACT	
	% Direct Wage	Cust. Wkr. Average	Month = 173 1/3 hrs.	Col./Univ. Janitor
Direct Wages				
Base		$6.22		$5.92
Shift Differential		.27		--
Total Subject to OPE		6.49		5.92
Other Payroll Expenses				
Retirement/Pension	11.87%	$ .77	$ .19/hr	$ .19
Retirement/Attribution	05.66%	.37	--	--
Medical Hospital	09.65%	.63	46.00/mo	.26
Dental	01.10%	.07	8.50/mo	.05
Life Insurance/Welfare	00.11%	.01	12.04/mo	.07
Personnel Division	00.99%	.06		--
FICA	06.90%	.45	06.90%	.41
SAIF	00.97%	.06	00.97%	.06
Unemployment	00.75%	.05	00.75%	.04
Total	38.00%	$2.47		$1.08
Total Payroll Expense/Hour		$8.96		$7.00
Annual Paid Hours	260 days x 8 hrs	2080 hrs	260 days	2080 hrs
Annual Payroll Expense		$18,636.80		$14,560.00
Annual Non-Productive Paid Hrs				
Vacation, through 5th year	12 d/yr	96 hrs	10 d/yr	80 hrs
Sick Leave	12 x .75 d/yr	72 hrs	none	0 hrs
Holidays	10 d/yr	80 hrs	7 d/yr	56 hrs
Other Paid Leave Days	1 d/yr	8 hrs	none	0 hrs
Sub Total	32 d/yr	256 hrs	17 d/yr	136 hrs
Rest Periods @ .5 hrs/day	228 d/yr	114 hrs	243 d/yr	121.5 hrs
Annual Productive Hours	2080-370	1710 hrs	2080-257.5	1822.5
Productive Cost/Hour	18636.80 ÷ 1710		14560.00 ÷ 1822.5	
	$10.90		$7.99	

Enclosure (1)

Construction Trade: Comparison of In-House vs. Contract Services
(Carpenter)

	Agreement Between OPEU and State of Oregon IN-HOUSE		Contractor Direct Labor Costs CONTRACT	
	% Direct Wage	Carp. Average	Group 1 Lowest	Carpenter
Direct Wages				
Base		$10.81		$16.19
Other Payroll Expenses				
Retirement/Pension	11.87%	$ 1.28		
Retirement/Attribution	05.66%	.61		
Medical Hospital	09.65%	1.04		
Dental	01.10%	.12		
Life Insurance/Welfare	00.11%	.01		
Personnel Division	00.99%	.11		
FICA	06.90%	.75	06.90%	1.12
SAIF	00.97%	.10	00.97%	.16
Unemployment	00.75%	.08	00.75%	.12
Fringe Lump Sum				3.47
Total	38.00%	$ 4.10		$ 4.87
Total Payroll Expense/Hour		$14.91		$21.06
Annual Paid Hours	260 days x 8 hrs	2080 hrs	260 days	2080 hrs
Annual Payroll Expense		$31,012.80		$43,804.80
Annual Non-Productive Paid Hrs				
Vacation, through 5th year	12 d/yr	96 hrs		
Sick Leave	12 x .75 d/yr	72 hrs		
Holidays	10 d/yr	80 hrs		
Other Paid Leave Days	1 d/yr	8 hrs		
Sub Total	32 d/yr	256 hrs		
Rest Periods @ .5 hrs/day	228 d/yr	114 hrs	260 d/yr	130 hrs
Annual Productive Hours	2080-370	1710 hrs	2080-130	1950
Productive Cost/Hour	31012.80 ÷ 1710		43804.80 ÷ 1950	
	$18.14		$22.46	

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